JOURNAL OF ANIMAL BEHAVIOR

VOL. 3 NOVEMBER–DECEMBER, 1913 No. 6

LITERATURE FOR 1912 ON THE BEHAVIOR OF LOWER INVERTEBRATES

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The experiments of Allee (1) were performed mainly upon *Asellus communis*. Specimens from streams gave a high percentage of positive rheotactic responses. Pond isopods, on the other hand, showed a weak positive rheotaxis, and were frequently indifferent. In general the oxygen content of streams was found to be higher than in ponds. That this fact may afford at least a partial explanation of the different responses of pond isopods and stream isopods is indicated by results of experiments which showed that the positiveness of the rheotaxis is decreased by lack of oxygen. In general agents that act as depressants (chloretone, potassium cyanide, carbon dioxide, low temperature, etc.) reduce the rheotactic response, while agencies that stimulate metabolism, such as oxygen, caffein and increase of temperature within certain limits, increase this response.

Bauer (2) has shown that the behavior of *Pecten iacobaeus* L. is unusually complex and shows many interesting adaptations to its habitual environment. This species feeds mainly on microscopic algae, and seeks well lighted situations which naturally afford more of its accustomed food. During the process of swimming, which is accomplished by opening and closing the valves of the shell, the animal is unable to orient itself to the rays of light. Orientation is effected when the Pecten comes to rest on the bottom, by forcibly expelling the water on the side that is turned away from the light. After being turned so as

to face the light, the animal begins to swim through the water for a short distance, then settles down, reorients itself and makes another excursion. Pecten frequently closes its shell upon the approach of a large moving object, and the experiments of the author have convinced him that this reaction is not a shadow reflex such as is performed by many other mollusks, but a reaction based upon the movement of the object in its field of vision.

The numerous tentacles that fringe the margin of the mantle are organs that are very sensitive to touch and chemical stimulation. If the tentacles come in contact with a starfish the mollusk commonly swims away. The juices of the starfish diffusing in the water evoke the same lively response. If Pecten, which commonly lies upon its more convex right side, is turned over it is able to right itself by opening and closing the valves of the shell. Bauer concludes from several experiments that both the eyes and the statocyst are concerned in the righting reaction.

Bohn (3) has discovered that in actinians pressure of the water in which they are contained tends to cause them to expand. Certain copepods and the larvae of the lobster may be caused to react negatively to light by only a slight increase of the pressure of the water.

Bohn (4) believes that there are two kinds of sensitivity, one to light, another to shade, corresponding to antagonistic chemical reactions. Causes that accelerate oxidations tend to make animals positively phototactic; causes that inhibit oxidations produce attraction to shade. Periods of sensitivity to light tend to alternate with periods of sensitivity to shade. Young lobsters are rendered temporarily positive to light by acids and more permanently positive by alkalis.

Planarians which had been illuminated on one side and which had been turning away from the source of stimulus were found by Boring (5) to keep turning toward the opposite side after being transferred to a situation in which the light was the same on both sides of the body. Apparently the more stimulated side had lost some of its sensitivity. After turning away from the light for a while the planarian begins to make sudden turns toward the light which for a time increase in frequency, but finally disappear. Boring considers these turns to be "a form

of compensatory muscular movement, initiated as a relief from the continued contraction of the muscles already involved in turning."

Chidester (6) gives a general account of previous work on the biology of the crayfish (with bibliography), and original observations on feeding, reactions to light, and behavior of young. Crayfish are positively phototactic in weak and negative in strong light. They are most active at night.

Clementi (7) has studied the effect of cutting the nervous cord and of removing parts of the central nervous system upon the movements of Julus. Merely cutting the ventral nerve cord does not destroy coördinated movements of locomotion; the wave-like movements of coördinated action of the legs pass over the region of the severed cord much as they do in a normal animal. Removal of the three anterior segmental ganglia of the ventral cord profoundly affects the coördination of the locomotor appendages, and destroys the possibility of performing certain reactions.

In the course of his extensive monograph on the Acinetas, Collin (8) gives a general account of the behavior of these organisms and discusses the mechanism of their movements.

Embody (9) has studied the distribution, food habits, mating behavior and general activities of several fresh water amphipods.

Ewald (10) finds that the larvae of *Balanus perforatus* are affected by sudden changes in the intensity of light. "Increase of illumination causes inhibition of locomotion, preceded by a slight acceleration; the result is a sinking. Decrease of illumination causes acceleration of locomotion." Green and yellow-green light are the most potent in evoking these reactions as well as in effecting orientations.

Increase of temperature tends to produce a negative reaction while decrease of temperature has the reverse effect. A sodium chloride solution isotonic with sea water makes negative animals positive. Potassium chloride has a similar but weaker effect, while an isotonic calcium chloride solution causes the larvae to swim about without regard to the light. Magnesium acts as an antagonist to sodium. If $MgCl_2$ is added to a pure Na Cl solution it tends to evoke a negative reaction. The hydrates of ammonia and sodium produce a negative reaction, while HCl, $H_2 SO_4$ and HNO_3 have the reverse effect; acetic acid and CO_2

have little influence on the reaction. Increase of concentration by the addition of NaCl or Mg Cl_2 had a strong positivating effect, while hypotonic solutions of these salts produced the opposite result. The action of various stains was tested, but the effects produced were small and of uncertain interpretation.

Dr. Franz (11) is of the opinion that the rôle of phototaxis in determining the vertical migration of marine animals is not only unproven but improbable. That fewer animals are caught in a net near the surface during the daytime is attributed to the fact that the animals can see the net better at that time and so escape from being caught. At night they are unable to avoid the net and are hence caught in greater numbers near the surface.

This conclusion is in part based on the author's conviction that phototaxis is frequently a product of artificial conditions of confinement in a laboratory. Many organisms, according to Franz, react to light in aquaria which do not show any phototaxis in their natural habitat. Phototaxis is based on movements of escape (Fluchtbewegung), and when it is manifested by animals in nature it is an expression of an effort to get into a free environment or to seek the protection of a secluded nook.

According to Hadley (12) only well fed lobsters of the fourth larval stage will respond to light. Hungry individuals do not burrow so readily as those which are well fed, but they are much more active in swimming. Clam juice in the water tends strongly to make the young lobsters swim at the surface, especially if they have been kept without food.

According to Hargitt (13) there is little relation between the position of the tubes of a number of sedentary annelids (*Protula protula*, *Hydroides pectinata*, *Potamoceras triqueter* and *Spirographis spallanzanii*) and the direction of the light that habitually falls upon them. In general, Hargitt's experiments confirm his previous results on these and other tubicolous annelids. There is a discussion of the relation of the results secured to the theory of tropisms and the general explanation of animal behavior.

Harper (14) has carried on experiments to ascertain how the geotropism of Paramecium is affected by feeding the animals with finely divided iron. As the particles accumulate in the posterior end of the body this part tends to sink downward, and

this causes the animal to swim upward unless the load is too heavy. As the particles of iron become more evenly distributed through the body the negative geotropism tends to disappear. A strong magnet placed at one side of a dish containing Paramecia which have ingested iron causes the animals to swim upwards until they reach a weaker part of the magnetic field.

Henri and Henri (15) and Henri and Larguier des Bancels (16) (17) in several papers have given an account of their experiments upon the reactions of Cyclops to ultra-violet rays. These rays stimulate the animals to rapid activity, but if the duration of the stimulus is too short no reaction is produced. When the stimulus is of longer duration the Cyclops respond uniformly after a certain interval of time, which remains remarkably constant for many successive experiments. The latent period is decreased as the intensity of the stimulus is increased. Starting with a stimulus which does not last long enough to evoke a reaction, it is found that if a number of stimuli are applied in rapid succession, the effect is the same as if the stimulus were applied continuously throughout a period equal in length to the sum of the partial stimulations. If the stimuli are separated by longer intervals, there is a partial summation of the effects, which diminishes with the increase of the interval until it is no longer apparent. The authors discuss the relationship of these results to certain phenomena of memory in man.

The sea-urchin *Arbacia punctulata* was found by Holmes (18) to react negatively to light of a great range of intensity, although it is occasionally positive in weak light. After it has ceased to respond it may be made to resume its phototactic movements by mechanical disturbance. Movements are effected by the combined action of the spines and tube feet, although the animal may crawl away from the light when either of these sets of organs has been removed. Arbacia responds to shadows by erecting the spines, while local stimulation by light causes the spines to bend towards the stimulated region. Strong light thrown upon the tube feet causes them to be withdrawn. Phototaxis is not dependent upon stimulation of both sides of the body. A sea-urchin which is stimulated only by a small spot of light will crawl away from the course of stimulus in a fairly direct line. Cutting the oral nerve ring, while not interfering with the

reactions of particular organs to light, destroys the phototaxis of the organism.

Issel (19) has studied the habits of a small isopod, Zenobiana, which lives in holes in marine plants which it is thought to excavate. The isopods are more active during the night. Shadows cause them to retreat quickly into their tubes. They are strongly thigmotactic and exhibit the instinct of feigning death. There are a number of interesting structural adaptations and instincts in relation to a tube-dwelling life.

Jackson (20) writes a general account of the natural history of *Hyalella knickerbockeri* (Bate), treating of general distribution and local habitat, color changes, size in relation to sex, methods and frequency of molting, breeding habits, food and feeding, enemies, thigmotaxis and locomotion.

Jacobs (21) finds the resistance of different species of Protozoa to CO_2 variable. The contractile elements in Vorticella and Peranema are soon paralyzed, but the cilia and flagella are more resistant. In Vorticella, however, the contractile elements are first stimulated and then paralyzed; the vibratile ones are temporarily stopped and then started again.

It is well known that leaves are commonly drawn either by the tip or petiole into the burrows of earthworms. According to J. Jordan (22) the worms do not examine various parts of the leaf as they were believed to do by previous observers, but they catch hold of the leaf at any point and attempt to draw it in. When leaves are seized by the side this attempt is usually fruitless, and only in those cases in which the worm comes to seize the leaf at some narrow part are the efforts of the creature successful. In most of the previous experiments on this subject the actual behavior of the worms was not witnessed, but Jordan has based his conclusions upon observation of the activities of the animals in weak light.

H. Jordan (23) finds that neither the marginal sense organs nor the margin of the umbrella of the jelly-fish Rhizostoma are necessary for the production of rhythmical contractions. Cyanea becomes more irritable to external stimuli after the margin of the umbrella is removed; removal of the sense organs affects the irritability of the animal but slightly. The author considers that the nervous centers of the margin have the function of regulating the reflex irritability of the animal.

Kew (24) finds that the pairing behavior of pseudoscorpions is in many respects similar to that of scorpions. Fertilization in Chelifer and Chermes is effected by means of a spermatophore.

The first part of Laubmann's (25) paper on the cutaneous sense organs of the Caridea is concerned with the structure and innervation of the sensory hairs on various parts of the body. The physiological experiments of the author showed that the chief organ of smell was the so-called olfactory branch of the first antennae, and that the second antennae and the mouth parts had an olfactory function also.

The locomotion of Peranema when swimming freely was found by Mast (26) to be quite similar to that of Euglena, but ordinarily when not strongly stimulated the flagellate crawls forward along the surface of some solid by wave-like contractions of its body combined with a rotary movement of the tip of the flagellum. When the flagellum encounters an object "the animal bends always toward the larger lip, then proceeds on a new course more or less at right angles with the old. The same response can be induced by contact stimulation of any part of the body or by chemical stimulation." Peranema frees itself from a confined situation by increasing the vigor of beat of the flagellum and by turning the body toward the larger lip.

Matisse (27) has discovered that in the earthworm *Allolobophora putris* the rapidity of locomotion not only varies with the temperature, but at any given temperature it is subject to somewhat complex rhythmical fluctuations. Within certain limits increase of temperature is accompanied by an increase of locomotor activity, which is attributed to the increased rapidity of chemical changes in the tissues. When kept at a constant temperature the worms showed, in addition to a constant decrease of activity, a diurnal rhythm, being more active in the morning and less active later in the day. And superimposed upon this are shorter rhythms of greater and less rapidity of locomotion while the worms are crawling about. The author attempts to correlate these facts with certain peculiarities of the action of catalytic and autocatalytic substances.

In a paper on the general life history of two ciliate infusorians Moody (28) has made some observations upon the behavior of these forms in relation to food. Both forms live upon a particular kind of prey and fail to react to other organisms.

Actinobolus attacks the infusorian Halteria while Spathidium captures *Colpidium colpoda*. If Spathidium is well fed it makes no efforts to capture food.

Moore (29) finds that negative phototropism in *Daphnia pulex* is caused by ultra-violet light below a certain wave length, and that the reaction may be reversed by the addition of small amounts of CO_2 and HCl.

Strychnine added to water containing positive and indifferent specimens of Diaptomus caused a negative reaction in one minute. Atropine produced the same change, but the effect was not so decided, while caffeine produced a positive reaction. Acids and camphor reverse the negative reaction caused by strychnine.

In two papers Orton (31) (32) describes the natural history and general feeding habits of *Crepidula fornicata*, with comparisons between the food habits of this species and those of other mollusks. Several years ago *Crepidula fornicata* was introduced upon the coast of England, where it is proving an enemy of the oyster since it lives upon the same kind of food and thrives in the same kinds of localities. The radula of Crepidula is not used directly in feeding as it is in most gastropods, but is used as a grasping organ for seizing the food. The food material, which consists of minute organisms in the water, is brought in much as in lamellibranchs by the action of cilia on the gills and mantle chamber which sweep currents of food toward the mouth.

Anemones will respond to a stimulus applied to the ectoderm of the base of the column by a contraction of the entodermic muscles of the mesenteries. By a method of staining with silver nitrate a nervous network may be demonstrated in the lamella of the column, and through this network a connection is established between the ectoderm and the mesenteric muscles. Certain responses in animals whose ectoderm has been anesthetized with magnesium sulphate are regarded by Parker as a non-nervous direct response of the muscles.

Pearse (34) has written an account of the general behavior of fiddler crabs, treating of burrowing, feeding, pugnacity, fear reactions and courtship. Like other crustaceans fiddlers show no social instincts, although they commonly live in close association. The males are pugnacious, attacking one another by means of their large chelae. Occasionally males attack females,

and sometimes the females wage ineffectual conflicts with one another. Although the males may perform various antics before the females during the breeding season, Pearse found no convincing evidence of the occurrence of sexual selection.

Polimanti (35) finds that many crabs feign death in various positions and assume various attitudes. The species that are habitually exposed show the response in a more pronounced form than species that bury in the sand or live symbiotically with sponges. The duration of the feint depends upon a variety of external stimuli, but is little influenced by the substratum, light, or visual stimulation of passing objects. The death feint is not a voluntary reaction nor a manifestation of hypnosis, but a special "tonic reflex."

Rynberk (36) in a general review of the subject of the segmental functions of the nervous system gives an account of the analysis of many of the instincts of the lower invertebrates.

In *Stenophora juli* Sokolow (37) finds that progressive movements are caused not by a contraction of myonemes, but through the secretion of gelatinous threads at the posterior end of the body. In acid media which dissolve these threads there is no progressive locomotion, although other movements of the body occur for which the myonemes are responsible. The rate of movement increases with temperature up to an optimum of 28° to 29° C., with maximum at 49° to 42° C., minimum at 4° to 5° C.

Vieweger (38) has made a detailed study of chemotaxis in Paramecium and Colpidium, treating especially of the influence of various combinations of chemicals upon the different tropisms of the animals.

Weymouth and Richardson (39) find that the food of *Emerita analoga*, the common sand mole of the sandy beaches of western North America, consists of microscopic organisms, strained from the water by means of the highly modified antennae which are furnished with numerous fine hairs. As the waves retire from the beach the Emeritas thrust out their antennae from the sand, and then draw them back again when the water has drained off; then they fold in the antennae, which deliver the food to the mouth parts, which are highly modified to deal with the catch of microscopic forms. The sand moles are well adapted by the form of the body and the character of the appendages for

burrowing in the sand, and there are specialized structures adapted to respiration in the peculiar habitat of these animals.

The earthworms tested by Yerkes (40) were induced to crawl through a passage which led to a second one running at right angles to it, so that the animals had a choice of crawling either to the right or to the left. One of these passages was furnished with sand paper and electric wires, so that the worms which crawled into this passage would encounter stimuli which would cause them to turn back. Most of the experiments were carried on with a single specimen which was given a certain number of trials a day for some months. The worm after from twenty to one hundred trials came to avoid the branch of the tube where it received a shock, but its subsequent behavior was far from constant. The habits of turning that were formed were found to persist after the removal of the first five segments of the body and hence the brain. As the brain regenerates the worm shows more initiative and variability in its behavior.

Whether the modified behavior of the worm studied rests upon the formation of associations or upon some other physiological factor or factors is a question difficult to determine in a creature like the earthworm, but if associative memory should be proven in this case it would afford the first instance of this faculty among animals so low in the scale of life.

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LITERATURE FOR 1912 ON THE BEHAVIOR OF SPIDERS AND INSECTS OTHER THAN ANTS

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TROPISMS

1. *Thigmotropism.* Wodsedalek (110) deposited a brick in a vessel of water. On top of this brick he placed a few small pebbles of different sizes. On these pebbles he balanced another brick in such a manner as to form a graduated space between the bricks. A large number of the nymphs of *Heptagenia interpunctata* Say were placed in the water. In a short time, all of these may-fly nymphs were clinging, dorsal side downward, to the under side of the uppermost brick. A stone, with several attached nymphs, was placed in a tin vessel of water and the temperature of the water gradually raised. When the temperature had reached 42° C. the nymphs began to leave the stone, and by the time it had reached 45° all had departed. A stone so large that a portion of it would project above the water, was placed in an aquarium in which a chunk of ice was kept. In a short time all of the nymphs in the vessel were clinging to the submerged portions of the stone. The stone was then heated from above. As the stone gradually became hot, one by one the insects let go; but as soon as they were cool, they returned to the stone. Occasionally one of these returning nymphs would turn away just before reaching the stone, and other nymphs leaped from point to point along the rock, as though seeking a cooler place. Most of the nymphs spent their time roaming back and forth between the hot stone and the cool water. Wodsedalek noticed that, when given the opportunity, a nymph would wrap itself about a small pebble and become so rigidly fixed in that position that moulting was impossible. These experiments and observations caused Wodsedalek to conclude that strong positive thigmotropism is the most pronounced feature in the behavior of these may-fly nymphs.

C. F. Curtis Riley (79) is convinced that dragon-fly nymphs are positively thigmotactic and that this causes them to collect in groups.

W. P. Gee (32) claims that the young of the scale insect *Lecanium quercifex* Fitch are pronouncedly positively thigmotactic. A young nymph was placed upon its back and an unhatched egg applied to its upstretched feet. The insect at once began to juggle the egg and continued to do so for nearly thirty hours. The egg hatched at the proper time; but the young insect had a hard time escaping from the grasp of the juggling scale.

2. *Phototropism.* Mast (57) states that the male fireflies studied by him always turned so as to face the glow of the female and then moved directly towards it.* He also noticed that the male continued to move in the direction of the glow even after it had ceased. Mast thinks the following mechanical explanation is justifiable. "If we assume * * * that there is in the male a specific response for the illumination of every surface of the eye; that is, that momentary illumination of the posterior surface is followed by a turning through 180° and then locomotion straight forward, the side of the eye by turning through 90° and then forward movement, the front of the eye by a forward movement alone, etc., it is not difficult to conceive all of these reactions to be purely mechanical reactions of the nature of unconscious reflexes." However, Mast does not consider these orientations tropisms in the sense of Loeb; for he writes: "Here we have a case in which it is clearly demonstrated that light does not act continuously in the process of orientation as demanded by Loeb's theories, a case in which it is also clearly demonstrated that a continuous action of the stimulating agent is not necessary to keep the organism oriented."

C. H. Turner (100) confined several of the mason wasps, *Trypoxylon albotarsus*, in wire cages and experimented on them with narrow bands of light, broad bands of light and cones of light. In some experiments direct sunlight and in others the beam of an electric projecting lantern served as the illuminant. Red, orange, blue and colorless lights were used. "As a rule, under the influence of a strong white light, these wasps would make active flights or else walk rapidly about." "When a light

* See Mast, under "Mating."

stimulus, no matter what the hue, followed one with a lesser brightness content, the wasps usually became active; but when it followed one of greater brightness content the wasps usually became inactive." "These responses were not tropisms, for the flights were pronouncedly random; there being no fixed relation between the direction of the movement and the rays of light."

By shifting an incandescent lamp from one end to the other of a glass dish and noting the responses of the scale *Lecanium quercifex* Fitch, Gee (32) thinks he has demonstrated that this scale is negatively phototactic.

According to C. F. Riley (79), dragon-fly nymphs are negatively phototropic to strong light.

During the year two papers, one by Hunter (43) and another by Hasebrock (39), have appeared which discuss the effect of the Roentgen rays upon the development of insects. The former experimented upon ticks, the latter upon butterflies. Hunter is convinced that the rays do not produce sterility.

3. *Geotropism.* Gee (32) arranged some thin sheets of cork in a vertical position and placed some scale insects, *Lecanium quercifex* Fitch, upon them. Invariably the insects crawled upwards, displaying, so he claims, positive geotaxis.

4. *Chemotropism.* Gee (32) tested the chemical responses of the scale insect *Lecanium quercifex* Fitch by placing, in the midst of a crowd of the scales, a drop of one of the following liquids: hydrochloric acid, nitric acid, ninety per cent. alcohol. In each case a marked negative reaction was produced.

SENSATIONS

Wodsedalek (110) is convinced that the nymphs of *Heptagenia interpunctata* Say cannot see small objects.

John Lovell (53) has published the results of some field work conducted to test Plateau's statement that "All flowers might be as green as their leaves without their pollination being compromised." Of the ninety-one green, greenish, brown, or brownish entomophilous flowers enumerated by Plateau only thirty per cent. were visited by bees, and some of these were conspicuous flowers. According to Lovell, in North America east of the 102nd meridian and north of North Carolina and Tennessee there are 1244 green or dull-colored flowers; of which 1021 are anemophilous or hydrophilous, while only 223 are entomophilous

or autogamous. Wind-fertilized flowers are small and usually greenish. The rose-colored flowers of *Gerardia purpurea* and flowers of the same species from which the corollas had been removed were placed near a bee-hive, but separated by a tumbler of water. Honey was placed in both. At first the bees collected from the perfect flower and neglected those from which the corollas had been removed. Bees were trained to collect from an unpainted board which was well supplied with honey. A blue slide, well supplied with honey, was placed on the ground three feet from the board. Honey was placed on a dandelion leaf which was growing three feet from the board and five from the blue slide. As soon as all of the honey had been removed from the board the bees began circling about it in widening curves. In twenty-five minutes five bees had begun to collect from the blue slide, but none had visited the dandelion leaf. Alongside of the dandelion leaf was placed an apple leaf that had been well supplied with honey. At the end of forty minutes one bee found the apple leaf. Bees were trained to collect from a board of the type used in the above experiment. Three feet from the middle of the board and forming an equilateral triangle with that point were two posts four and a half feet high. On the top of one post the investigator placed so much honey that it ran down the sides; on the top of the other he placed a scentless yellow *Helichrysum bracteatum* five inches in diameter. Three minutes after all of the honey had been removed from the board, three bees and one fly were on the flowers, but none was on the pole. The poles were now interchanged and a *Helichrysum bracteatum* only one inch in diameter was placed on the pole that had contained no flowers. Notwithstanding its changed position, the large and more conspicuous object received the greater number of visits. Bees were again trained to feed from a board of the type mentioned above. On the ground, nine feet from the board, Lovell placed a blossom of *Helichrysum bracteatum* containing honey. At the same distance on the opposite side of the board, he placed a red Astrachan apple leaf upon which he had put some honey. Several bees collected honey from the flower; but none visited the apple leaf. The observations recorded in the beginning of this paragraph and a series of experiments, of which the three just described are types, induced Lovell to form the following conclu-

sions: (1) Green flowers are not well adapted to entomophily. (2) As a rule they retain the power of self-fertilization. (3) The few insects that sparingly visit them usually belong to the less specialized families. (4) The fact that bees have been observed feeding on over-ripe or on decayed fruit, or on the glandular secretions of the vegetative organs of plants, or on the secretions of aphidae, or on greenish or brownish flowers, or on dull-colored receptacles which have contained sugar or sweet liquids, affords no evidence that conspicuousness is not an advantage to entomophilous flowers. (5) Any surface, whether bright or dull, on which there is nectar or honey will be visited by bees for stores after these liquids have once been discovered, but they will not be discovered as quickly on a surface which does not contrast in hue with its environment as on one which does. (6) When, under similar conditions, bees are given a choice between a conspicuous and an inconspicuous object they exhibit a preference for the former. This preference is sufficiently marked to account for the development of the color contrast in flowers. (7) As pointed out by Knuth, in the absence of control or comparative observations, the experiments and observations of Plateau on green or greenish flowers are fallacious and do not prove that "All flowers might be as green as their leaves without their pollination being compromised."

2. *Auditory.* Regan (76) has conducted a series of experiments to test the auditory powers of *Liogrylus campestris.*

EMOTIONS

Stubbs (94) discusses fear in insects.

Wodsedalek (108) arranged a large number of small aquaria, each containing a single nymph of the may-fly *Heptagenia interpunctata* Say, in different parts of the same room. Six of these specimens were roughly handled three times a day; three were disturbed once daily; three, once in three days; and six, not at all. The specimens that had been roughly handled three times a day made agitated movements whenever the hand of the investigator was passed over the water, and, in some cases, as soon as he approached the aquarium. Such behavior was almost never exhibited by nymphs that had been handled only once a day or less. It seems that the investigator is justified in concluding that these are fear reactions. "These results seem

to show that the nymphs formed few, if any, associations with pain resulting from a single daily disturbance. * * * In the forms disturbed several times a day, however, even after making liberal allowance for accidental movements, there remains abundant evidence that the nymphs learned to associate my presence with discomfort."

MATING INSTINCTS

S. B. Oliver (67) reports some abnormal matings of insects; S. B. Doten (24) discusses the relation of food to the reproductive activities and the longevity of certain hymenopterous parasites, and C. H. Turner (99) gives a photograph of the copulation of *Ammophila abbreviata*.

Robert Matheson and C. R. Crosby (58) observed, on three different occasions, *Caraphractus cinctus* Walker copulating beneath the surface of the water.

In a paper containing some valuable data on the longevity of saturnid moths, Phil and Nellie Rau (75) state that mating has no effect on the duration of life of the male Cecropia moth; but that, in six different lots, the unmated females lived longer than those that succeeded in mating.

According to Wodsedalek (109), on the day of emerging, the female of the museum pest *Trogoderma tarsale* Melsh avoids the male. On the following day she is submissive. At that time the male caresses the abdomen of the female with his antennae and then suddenly turns and brings the tip of his abdomen in contact with hers. These insects are both polyandrous and polygamous.

During the year two investigators, F. A. McDermott (54, 55) and S. O. Mast (57), working independently, have decided that the photogenic function of fireflies is a mating adaptation. Both of McDermott's papers are corrections of and additions to a former paper;* Mast's paper discusses in detail, the mating of *Photinus pyralis*. The following paragraph contains an epitome of Mast's paper.

Late in the afternoon, but while it is yet light enough to see, both sexes of the fireflies emerge from their subterranean crevices. The females climb blades of grass, or other uprights, and

* McDermott, F. N. A Note on Light-Emission of Some American Lampyridae. *Canad. Entom.*, 1910, vol. 40, pp. 357-363.

rest thereon. The males fly leisurely about, at a height of from one to two meters, emitting, at regular intervals, flashes of light. If the male glows within five or six meters of the female, she twists her body so as to have the luminous surface of her abdomen face the male and then glows in response. The male then turns directly towards the female, glows again and moves directly towards her, glowing intermittently as he flies. To each glow the female responds in kind. Arriving near the female, the male alights, runs about in an excited manner and glows frequently. Sooner or later the antennae of the excited insects touch and then the fireflies mate. Immediately the glowing ceases. When females were enclosed in air-tight glass jars, the males found them readily. This caused Mast to conclude that smell plays no part in bringing the insects together. Two sealed jars containing male fireflies and one containing females were placed on the ground. The males of the two jars were always in plain view of each other; but, by means of an opaque screen, the females were hidden from first one and then the other of the sets of males. The males exposed to the females glowed repeatedly; but the others glowed only after long intervals. This caused him to conclude that the males do not respond to the glow of other males. Other experiments showed that the female will respond to any intermittent glow, even when produced by artificial means; but the males respond only to the glow of the female.

NEST-BUILDING AND MATERNAL INSTINCTS

Cosens (22) gives some interesting information about the galls of numerous insects, and Casteel (16) describes in detail the manipulation of wax scales by the honey bee.

Hungerford and Williams (42) describe the nests of the following hymenopterous insects: *Pogonomyrmex occidentalis* Cress., *Chlorion caeruleum* Drury, *Bembex sayi* Cress., *Trypoxylon texense* Sauss., *Crabo interruptus* St. Fargo, *Odynerus annulatus* Say, *Loxostege stiticalis*, *Odynerus geminus* Cress., *Odynerus foraminatus* Sauss., *Polistes variatus* Cr., *Halictus occidentalis*, *Anthidium maculiforus* Smith, *Dianthidium concinnum*, *Dianthidium curvatus* Smith, *Megacheli Sp.*?, *Melitoma grisella* Ckll., and Porter, *Anthophora occidentalis* Cress., and *Ammophila sp.*? To students of the behavior of the hymenopterous insects, all of

the data will prove of interest. The authors' description of the nest-building of *Odynerus annulatus* Say is intensely interesting. In digging its nest this species moistens the soil with water, removes a small portion of the moistened soil and with it begins to construct a turret around the spot. Some more water is added and another small portion of the soil is removed and added to the turret. This is repeated over and over again and the turret, which is smooth on the inside and rough on the outside, grows apace. As the work advances only a part of the pellets removed from the burrow are built into the turret. The others are carried a distance of from four to six feet and dropped. Whence comes the water to moisten the soil? The wasp brings it, in her mouth, from a nearby lagoon. These investigators contribute additional proof, if such be needed, of the tool using instinct of the Ammophilae. They found one species of Ammophila using a stick to tamp the dirt on its burrow and another species using the tibia and tarsus of a small locust for the same purpose.

In his new book, Comstock (21) describes the webs, and in some cases the web-making activities of a large number of spiders, and, in a second contribution (20) he discusses, in the following manner, the probable evolution of the spider web. Some spiders in constructing their webs use several distinct kinds of silk, for the elaboration of which complicated spinning organs have been evolved. At least seven different kinds of silk are spun by spiders. From the few silken strands used by Pholcus to fasten her eggs together to the dense sheets used by others to construct elaborate egg-cases, silk in some form is used by all spiders in caring for their eggs. This was probably the primitive use of silk. Spiders living in burrows strengthen them by means of silk; some construct silken covers for the burrow and others build silken turrets. The most important step towards real web building was acquiring the habit of spinning a drag-line. "The step from drag-line to web is not a great one. A spider spinning a thread wherever it goes would make a web if, by chance, it moved about in a limited space, as in some nook in which it had taken up its abode. In such a web insects would be trapped, and thus might arise the habit of building webs for the purpose of trapping insects." The simplest webs are irregular and constructed out of dry silk like that used for

the drag-line. The web of Pholcus is a good example. The webs of the sheet-web builders are constructed of this kind of silk; but they have a more or less definite form. Slightly higher than these and constructed of the same kind of silk are the webs of certain members of the Agelenidae, which have a definite shape and a funnel-shaped retreat. These webs of dry silk simply impede the progress of the insect and enable the spider to capture them. To assist in holding the snared insects, many spiders secrete a viscid silk. Among the webs constructed in part of viscid silk there are evidences of evolution. The webs of the Theridiidae are almost as simple as those of Pholcus; but the inmate swathes a viscid fluid about its prey. Other spiders construct viscid bands or viscid threads in their webs. Of these webs there are two types; one in which the portion constructed of dry silk is comparatively generalized and in which the viscid silk is supported by a specialized band; and another in which the foundation of dry silk is highly specialized and in which the structure of viscid silk has remained comparatively simple. In each class the webs may be arranged in a series indicating the path of evolution. Since this viscid fluid is produced by the lobed glands in the Theridiidae, by the cribellum glands in the Cribellatae, and by yet other glands in other spiders, Comstock claims that this viscid fluid has arisen, independently, at least three times. In addition to describing the web-building behavior of spiders, Comstock gives a key for recognizing groups of spiders by their webs.

Weiss (106) describes the egg-laying of *Lixus concavus*.

Matheson and Crosby (58) describe the oviposition of *Limnodytes gerriphagus* Marchal and *Caraphractus cinctus* Walker.

Pierce and Holloway (73) state that *Chelonus texanus* Cress. deposits its eggs in the egg of the host insect; but that the parasite emerges from the larva which develops from the egg.

FOOD-PROCURING AND DEFENSIVE INSTINCTS

Campion (14) describes the feeding habits of the scorpion flies; Cockerell (17) of *Dysdercus mimus* Say; Hungerford and Williams (42) of the young of *Ammophila* sp.?, *Chlorion caeruleum* Drura, *Trypoxylon texensis*, *Crabo interruptus* St. Fargo, *Odynerus annulatus* Say, *O. geminus* Cress., *Halictus maculifrons, Dianthus concinnum;* Moore (62) of a large number of

caterpillars; Riley (80) of dragon-fly nymphs; Turner (100) of *Trypoxylon albotarsus;* Weiss (106) of *Lixus concavus*; Wodsedalek of the nymphs of *Trogoderma tarsale* Melsh (109) and of *Heptagenia interpunctata* Say (110).

Two investigators, Sladen of England and Casteel of this country, have contributed articles on the behavior of the honey bee in pollen collecting. F. W. L. Sladen (87) says that the pollen is gathered directly upon the metatarsal brushes. By scraping the inner sides of the metatarsi the pollen is compacted in the corbiculae. In spite of Cheshire's statement to the contrary,* Sladen asserts that there is no crossing of the legs.

At the beginning of his article, Casteel (15) emphasizes the well-known fact that bees do not combine pollen collecting with honey gathering. Following that statement comes a detailed account of how pollen is collected. In moving about among the stamens, some pollen clings to the hairs of the body and of the legs; but the greater part of the pollen is collected by the mandibles and tongue. The pollen collected by the hairs of the body and of the legs is dry; that collected by the mouth-parts is moistened with honey supplied by the mouth. The first pair of legs collects the dry pollen from the head region and the moist pollen from the mouth-parts. The second pair of legs removes the pollen from the ventral side of the thorax and receives that which has been collected by the first leg. The third pair of legs collects the pollen from the abdomen and receives that which has been collected by the second pair of legs. The third pair of legs now scrape the pollen from the the combs and sides of one into the corbiculae of the other. The moisture which has been supplied by the mouth causes it to adhere. In unloading the bee grasps one edge of the cell with her forelegs and arches her abdomen until its posterior edge rests on the opposite side of the cell. The middle legs then shove the pollen mass from the third legs into the cell. Usually another bee enters the cell, breaks the pellets with her mandibles and tamps down the mass in the bottom of the cell. She probably adds more fluid.

C. H. Turner (98) found some orphan *Polistes pallipes*, that he had raised from the larval stage, so tame that they would accept honey or insect larvae when offered to them on glass

* **Bees and Bee Keeping, vol. I, p. 132.**

rods, in forceps, or even upon the fingers. Belt writes: "A specimen or *Polistes carnifex* was hunting for caterpillars in my garden. I found one about an inch long and held it up towards it on the point of a stick. It seized it immediately, and commenced biting it from head to tail, soon reducing the soft body to a mass of pulp. It rolled up half of it into a ball and prepared to carry it off." Turner observed that the behavior of *Polistes pallipes* is quite unlike this. "Lepidopterous larvae captured for food are not stung. Grasping the caterpillar with her fore feet, the wasp rotates it on its longitudinal axis and gradually elevates it while she malaxates its posterior end until her jaws are filled with a ball of pulpy matter. The remainder of the insect is dropped."

Croft (23) observed a notodontid attacked by a wasp, and E. O. Essig (25) has discussed several natural enemies of the citrus plant louse.

To test the protective value of vapors emitted by certain bugs, Girault (34) performed a number of experiments. Certain bugs were confined to homoepathic vials for from three to twenty-four hours. They were then removed and some insect corked up in each vial. Control insects of the same species were placed in clean vials. Ants, beetles, plant lice, etc., were tested in this manner. The odors of certain bugs had no effect on the species studied; but the odor of others caused stupefaction, convulsions and, in some cases, death. Girault does not claim that these experiments settle the protective value of these odors; but that they demonstrate that the vapors emitted by certain bugs are highly noxious to various forms of insect life.

SOUND PRODUCING ACTIVITIES

Butler (12) describes the stridulation of some British bugs.

Recently two investigators, Omensetter and Stephan, have produced papers on the speech of insects. Omensetter's paper (68), which seems to be a compilation, describes the sounds produced by many insects belonging to the Lepidoptera, Orthoptera, Hymenoptera, Coleoptera, and Neuroptera. He writes: "That pleasure or pain makes a difference in the tones of vocal insects is not improbable, but the organs of hearing are not fine enough to catch all their different modulations."

In his papers Stephan (91, 92) confines himself to the Lepi-

doptera. Aeronia produces sound by striking one wing against the other. *Cozistra membranacea* produces sound by means of its wings. *Parnassius apollo* L. produces tones by rubbing the tibia against the hind wings. The male *Thecophora fovea* Tr., when flying, makes sounds by means of an uncovered small cavity in the middle of the hind wing. *Nyctipo hieroglyphia* Dr., *Anisoneura sphingoides* Fld., and *Potamorpha manilia* Cr. produce sounds by rubbing the narrow concavity of the fore-wing over an enlarged structure on the hind wing. The male *Lymantria monacha* L. makes a noise so loud that it can be heard, when held at arms' length, in a closed fist. In stressing the mode of sound production used by the death's head moth, he reminds us that, in 1737, Reaumer claimed that the sound was produced by rubbing the proboscis upon the inner edge of the base of the palpi; that, in 1867, Landois stated that it was produced by rubbing the inner surface of the palpi upon the proboscis; that Wagner, in 1838, and Landois, in 1875, claimed that in front of the stomach there is a bladder which usually is filled with air, and that the expulsion of this air across the proboscis causes the tones. This explanation is supported by the fact that compression of the dead body of a death's head moth that has not become rigid will produce the sound. Stephan seems to support this last interpretation. Several witnesses should be sufficient to establish this matter; but, to a student of insect behavior, this method of sound production is certainly unique; for he has come to believe that the strident sounds of insects are always instrumental and never vocal.

LETISIMULATION*

C. F. Riley (79) states that many of the dragon-fly nymphs studied by him letisimulated.

Wodsedalek (109) discovered that the larvae of the museum pest *Trogoderma tarsale* Melsh letisimulates when disturbed. The feint usually lasts from a few seconds to half a minute. The adults, when disturbed, feign death for a much longer time; among them the average is thirty seconds, but it may continue for fifteen minutes.

* This word, which has not yet come into common use, was first used by Weir, in 1899, in his book on "Dawn of Reason," page 202, to designate the death-feigning behavior of animals. Now that stress is being placed on animal behavior, it seems to me that the term should be revived.

According to Wodsedalek (108), rough handling of the ephemeridae nymphs *Heptogenia interpunctata* Say produces letisimulation. The time of the feint varies from a fraction of a minute to fifteen minutes. The average is between two and three minutes. Prolonged stroking of the nymph on the sternum or on the ventral side of the abdomen will prolong the feint. By such means a feint has been prolonged for an hour. A touch with a smooth object tends to prolong the spell; a tap with a sharp one arouses the insect.

Gee and Lathrop (31) describe three methods of inducing this form of behavior in *Contrachelus nenuphar* Herbst: (1) dropping them from a height in the air; (2) compressing, at short intervals, the lateral surfaces of the abdomen and thorax; (3) grasping the insect between the thumb and forefinger and suddenly blowing upon the ventral surface of the abdomen. Two distinct postures are assumed by the letisimulating individuals. In one type the individual draws the thoracic appendages closely against the ventral surface of the body. The first pair of legs extend forwards and are pressed against each side of the proboscis. The closely flexed second and third pairs of legs are held securely against the ventral side of the abdomen. In the other type the legs are folded closely together and held somewhat at right angles to the line of the body. The tarsi of the first and of the second pairs of legs are drawn tightly against the tibia; but, in the third pair, they are held approximately parallel to the ventral surface of the thorax. In the first type the pose resembles the attitude of insects that have been starved to death or killed by slow poison. These investigators succeeded in causing one individual to letisimulate fifty-three times; but, after the first few times, the duration of each successive feint was gradually reduced until the animal would not letisimulate at all. To test the influence of temperature, letisimulating individuals were placed in a glass and held over a flame. In every case the individual quickly recovered. This is unlike DeGeer's experience with the beetle *Anobrium pertinax;* which, he claims, could be roasted over a slow fire without recovering. Gee and Lathrop find that a low temperature increases the duration of the death feint, thus agreeing with Fabre's work on *Caponoides tenebrinicnis* and Holmes' work on *Ranatra.* It was found that letisimulating individuals, when placed in an atmos-

phere saturated with ether, chloroform, or carbon dioxide, recover at once. One by one, the appendages of eight letisimulating individuals were removed. With two exceptions, these showed no signs of recovering from the feint until several minutes after the operation. The abdomens were clipped from several individuals; slight twitchings of the tarsi were the only movements produced by the amputation. Seven letisimulating individuals were decapitated with sharp scissors. Immediately the legs relaxed and righting movements were made. These investigators remind us that letisimulation occurs in almost all orders of insects; that Holmes observed it in an amphipod crustacean, and Andrews in the crayfish. It occurs rarely among fishes and to some extent in the amphibia. It occurs in several reptiles and birds and in a few mammals. Gee and Lathrop agree with Holmes and with the Severins that this form of behavior has developed out of thigmotactic propensities.

DISEASE SPREADING INSTINCTS

W. E. Britton (5, 6), C. T. Brues (10) and J. H. Paine (70), have published helpful popular articles on the relation of insects to diseases.

Jennings (45) has discussed the method of controlling the mosquitoes of the tropics, and W. E. Britton (6) the methods of combating those of our Connecticut coast. The methods advocated are well known to entomologists.

C. T. Brues (11) gives a tabulated list of the diseases spread by insects and of the insects that spread them. He gives the following reasons for believing that infantile paralysis is caused by some insect: (1) the sporadic occurrence of the cases is not easily explained on the basis of ordinary contact infection; (2) the seasonal distribution of the disease, showing the largest number of cases during the warmer months; (3) its failure to spread rapidly where many children are in close contact; and (4) the characteristic rural nature of the disease. He gives reasons why it is improbable that this disease is spread by either the mosquito, the stable fly, the horn-fly, or fleas. He suggests that it is spread by the tick; but he could find no conclusive proof of this.

C. H. T. Townsend (96) thinks that verruga fever is spread by ticks in the same manner as the Rocky Mountain spotted fever.

According to Wm. Moore (64), "One of the most important and interesting problems in economic entomology is the rôle played by ticks in the spread of certain diseases and how these ticks may be destroyed." "In South Africa it is not one tick and one disease which must be dealt with, but a number of ticks producing a number of different diseases." The blue tick causes Texas cattle fever and spirochaetosis; the Bont tick induces heart-water disease in sheep, goats, etc.; the dog tick spread malignant jaundice among dogs; the brown tick transmits East Coast fever and gall sickness to cattle and may transmit Texas cattle fever; the Cape brown tick causes East Coast fever; the black pitted tick transmits East Coast fever and gall sickness and may spread spirochaetosis; the red tick is a carrier of East Coast fever, gall sickness and the biliary fever of horses. Moore discusses the life-histories of all of these ticks and gives methods of combating them. What he considers the most successful remedy is weekly dipping of the animals in a sufficient amount of the following mixture: three pounds of soft soap, one gallon of kerosene, four ponds of arsenite of soda, and four hundred gallons of water.

Frederick Knab (47) has well said: "The study of the rôle of blood-sucking insects in the transmission of diseases is a recent one, and it is still to a large extent vague and chaotic. Its teachings are not only built up largely on hastily collected and faulty data, but they are replete with errors. Many of the investigators not only have lacked the necessary knowledge of biology, but the mastery of detail, along with a broader view, which is eminently necessary in such work. Since the discovery that certain blood-sucking insects are the secondary hosts of pathogenic parasites, nearly every insect that sucks blood, whether habitually or occasionally, has been suspected or considered a possible transmitter of disease. * * * In order to be a potential transmitter of human blood-parasites, an insect must be closely associated with man and normally have opportunity to suck his blood. It is not sufficient that occasional specimens bite man." There is "a certain class of blood-parasites and transmitters which apparently do not conform to the principles laid down above. One class are the diseases transmitted by ticks, where the parasites are directly transmitted from the tick host to its offspring, and where, for this reason,

the insect remains a potential transmitter for a very long period. Another class are the trypanosomes which apparently thrive in a number of different vertebrate hosts and may be transmitted from cattle or wild beasts to man. But the observations on this point are by no means conclusive and it is quite possible, as has been repeatedly suggested, that a number of organisms, different but indistinguishable, are involved. It may prove that revision of data, from the present viewpoint, may materially alter our conceptions on the subject."

PARASITISM

Knab (48) reports a fly that is parasitic on man.

Girault (34) records some simple experiments which he performed with the human body louse.

Matheson and Crosby (58) discuss the habits of three hymenopterous egg parasites.

Ewing (27) gives a classification of parasites that covers two octavo pages. In the Acarina he finds evidence that parasitism has arisen in the following three ways: (1) by predaceous forms beginning to prey upon forms that are larger than they; (2) by scavengers passing from feeding on dead bits of animal and of plant tissues to feeding on the same tissues attached to a living organism and thence to feeding on the living organism; (3) by forms originally adapted for sucking the juices of plants, transferring their operations to animals. He gives a list of parasites and their hosts, and, in tabulated form, he records the duration of life of many mites after being removed from the body of their host.

LOCOMOTION

Bervoets (3) has published a short article on the flight of insects, and Collinge (19), a short note on the locomotion of the young of *Pulvinaria vitis* var. *ribesiae*.

H. W. B. Moore (63) describes the locomotion of a large number of caterpillars.

Matheson and Crosby (58) describe the behavior of three different species of American hymenoptera which swim, submerged in water, by means of their wings. These species are: *Hydrophylax aquivolans* M. and C., *Limnodytes gerriphagus* Marchal and *Caraphractus cinctus* Walker.

During the year Severin and Hartung (84) set free near Honolulu 2,000 male Mediterranean fruit flies which had been marked by removing a portion of a leg. Light traps for recapturing them were placed in definite situations. These investigators found that the wind had a marked influence both on the direction of the flight and on the distance flown. In time of calm, the flies flew in all directions, but when the wind was blowing, the flies drifted with it. In no case did they attempt to orient themselves against even the slightest breeze.

H. Osborn (69) expresses some thoughts on the flight of insects; which reflections he claims are suggestive rather than exhaustive. In the usual explanation of the flight of insects, the mechanism is considered essentially a plane with a rigid anterior border, a flexible hinder border and a vertical movement. At each downward stroke of the wings the air in escaping backwards and upwards propels the insect forward. Aside from the directly forward flight, insects are able to hover and even to fly backward. Osborn rightly concludes that this hovering and this backward flight are not explained by the above formula. He offers the following explanation of hovering and backward flight. There is a forward and backward movement of the wings which permits the angle a wing makes with the body to be varied from 90° to 45° or 30°. By this device the rigid portion of the anterior border of the wing is shifted so that the flexible apical and posterior margins have a different extent and must present a varying pressure upon the air. This rotation will allow varying degrees of forward and backward pressure. The attitude assumed by the wings of many insects after death is evidence that such a mechanism actually exists. The extent of the rotation differs in different groups of insects. The shape of the wing functions also. Broad winged insects neither hover well nor fly backwards well; while narrow winged hexapods excel in both styles of flight.

MISCELLANEOUS INSTINCTS

In years that are past so many abortive attempts have been made to find a true queen of the common northern termite that many had come to believe there were no true queens in our species. This year, however, such a queen has been found

and the credit goes to T. E. Snyder (90). It was found deep in the ground.

Mace (56) has conducted experiments to test the influence of weather upon the honey bee. The hive was weighed from day to day and the results compared with the weather conditions. He arrived at the following conclusions: (1) high winds cause great loss among the colonies; (2) during the honey flow in the early part of the season, weak colonies should have their brood space contracted so as to conserve all of the heat possible; (3) as soon as the brood combs are well covered with bees and the weather is fine, the supers should be put on and covered up warmly.

Cannibalism. According to Weiss (106), *Lixus concavus*, the rhubarb cuculio, lays a great many eggs in the stem of *Rumex crispus* and most of these hatch; yet, except where more than one stem is attached to the same root, not more than one larva is ever found in a root. The cannibalistic habits of the larva explain this. As soon as a larva hatches it eats out a little chamber above the egg cavity and then proceeds to mine an irregular passageway to the root. Any eggs encountered on the way are devoured. In the root it excavates a cavity and continues to feed until full grown. Any belated larva that arrives at the roots is devoured by the cannibal domiciled there.

C. F. Riley (79) reports that dragon-fly nymphs are cannibals.

By restricting them to a honey diet for a few days, Turner (98) caused a small colony of *Polistes pallipes* to display cannibalistic habits. "Bit by bit, they removed the cap from a pupal cell, decapitated the inmate and ate the contents of its thorax."

Ecology. Shelford (85), as a result of field studies extending over several years, concludes that the land animal life of a place is largely determined by the kind of vegetation growing there. Following Cowles' lead, he recognizes the following stages in the evolution of a wood: (1) the cottonwood stage; (2) a transition between the cottonwood stage and the pine stage; (3) the pine stage; (4) transition between the pine stage and the oak stage, or mixed pines and oaks together with open spaces in the oak area; (5) the black oak stage; (6) the red

oak stage (the red oak associated with the black oak and white oak in the earlier stages, and with shag-bark hickory, in the later stages); (7) the beech and maple stages. In each of these plant communities the animals live in five or more less distinct strata: (1) beneath the ground (subterranean stratum); (2) at the surface of the ground (ground stratum); (3) herbaceous vegetation, low shrubs, etc., (field stratum); (4) shrubs and young trees (shrub stratum); (5) trees (tree stratum). In considering different communities like strata should be compared. Many animals invade several strata; they should be classified primarily in the stratum in which they breed and secondarily in the stratum or strata in which they feed or forage. Shelford gives a rather exhaustive discussion of both communities and strata, and gives tables showing the distribution of animal life in both. The following epitome of his conclusions will be of interest, not only to students of insect behavior, but to all field zoölogists. (1) The development of a forest on sand or other mineral soil is accompanied by an almost complete change of animal species and probably by a complete change of animal mores. (2) Forest development is accompanied by marked changes in the soil and in physical factors; animal distribution is more closely correlated with differences in physical factors than with the species of plants. (3) For animals dwelling in the soil, the moisture equivalent or the wilting coefficient for a standard plant is the best index of the moisture available to the animals. (4) The evaporating power of the air is probably the best index of the conditions of the atmosphere. (5) The rate of evaporation, temperature, etc., varies much in different communities and in different strata of the same community. (6) Land animals are comparable to small non-rooted plants. (7) The succession of all of the animals of a forest community is comparable in principle to that in ponds; it is due to an increment of changes in conditions produced by the plants and the animals living at the given point. (8) The various animal species are arranged in these communities in an orderly fashion and the dominating animal mores are correlated with the dominating conditions. (9) Taxonomic species usually have the same mores, although the same species often has different mores under different conditions, and different species may have the same mores. (10) Species and mores are not synonymous.

(11) Ecology considers together mores that are alike or similar in their larger characters.

Hibernation. At a depth of about three inches, Blaisdell (4) found sixty-four specimens of the tiger beetle *Cincindela senilis* hibernating beneath a stone. The mouths of the burrows were at the edge of the rock, and at each there was a little pile of dirt that had been excavated in digging the burrows. Each burrow had one main gallery with branches leading distinctly to the edge of the stone. The branches that did not end blindly were closed with dirt. The main gallery, which was not more than half an inch below the surface, came to the surface at certain points. Blaisdell thinks the gallery became community property through an accident.

Mayer (59) discusses the hibernation of *Pyremeis atalanta.*

Migrations. Grossbeck (37) discusses the migration of the Argillacea of Alabama.

Moulting. Ewing (26) has the distinction of being the first to describe the moulting of our common red spider. The larva moves its body back and forth and sidewise. Suddenly the skin of the dorsal surface bursts just back of the scapular groove. In an instant some of the bristles of the thorax are released and the eyes of the emerging nymph burst into view. Following a series of side movements, the hindmost legs are extended laterally and slightly anteriorly. The body wriggles for a moment, then the anterior portion begins to be withdrawn from the old larval skin. The movement is slow until the first pair of legs appear, then the nymph suddenly pulls loose from the anterior portion of the old skin and walks out of the posterior portion. The total time consumed is only four minutes.

Turner (98) describes an abortive attempt of a pupa of *Polistes pallipes* to moult.

Phosphorescence. Green (35) describes the phosphorescence of the beetle *Harmatelia bilinea.*

See McDermott and Mast, under "Mating."

Singh and Maulik (86) found that the so-called phosphorescence of the fireflies would affect the photographic plate through wood, dark brown leather, black paper, or flesh; but that it would not affect the plate through glass. Hence they

conclude: "The light of this insect cannot, therefore, be taken as phosphorescent. It may be, perhaps, premature to conclude that some rays emitted by these insects are X-rays, but it may be safely asserted that these rays are at least similar to the X-rays and ultra-violet light in so far as they may render certain opaque media transparent and are intercepted by glass."

Homing. On departing from a place that it is likely to revisit, *Polistes pallipes* makes a flight of orientation. This has caused Turner (98) to conclude that associative memory guides this wasp home.

Respiration. Babak (1) discusses the breathing of *Culex.*

Brocher (7, 8, 9) devoted about four years to the study of the respiration of certain aquatic hymenoptera. He paid especial attention to *Elmis aeneus.* He finds that this species obtains the necessary oxygen, not from the air direct, but from submerged plants. Bubbles of air obtained from the plants cling to their bodies. Brocher describes at length the organs by means of which this mode of respiration is carried on.

MEMORY AND LEARNING BY ASSOCIATION

Turner (101) noticed a digger wasp trying to drag a spider to her nest. In her path she encountered a tall fence, over which, on account of a horizontal scantling, she found it impossible to drag her burden. Turning about, she dragged the spider along the fence until the corner of the yard was reached. Then she passed through the pickets of the front fence to the outside. Depositing her burden on the ground, she made a flight of orientation and flew off to the nest. Returning, she dragged the spider along the ground towards the nest, and, after overcoming numerous minor hindrances, she succeeded in depositing the spider in her nest. The line by which she finally reached the nest made an angle of about 45° with the line along which she originally attempted to drag the spider home. The investigator concludes: "The behavior of this wasp does not harmonize with the theory that the movements of wasps are tropisms in the sense the term is used by Loeb; nor is it apparent how it can be the result of what Thorndike calls 'trial and error' movements. Her whole behavior is that of a creature

struggling against obstacles to attain a certain known place in a known environment."

Two investigators, Szymanski and Turner, have conducted experiments to test the ability of the common roach to form new associations. The general method used was practically identical, not because one had copied from the other, but because each had been inspired by Yerkes' work on mice. A bottomless glass pen, containing two compartments, one light and one dark, was placed on a specially arranged electrical shocking platform. In the lighted division of the pen marked roaches were placed one at a time. Following its instinctive tendency, an untrained roach would rush into the dark chamber. Immediately an electric shock was given, which caused the roach to return to the lighted portion. In the lighted compartment it would become restless and, sooner or later, it would enter the dark section. There it received another shock which caused it to return to the light. Every time it reëntered the dark chamber it was driven out by means of electric shocks. Soon it would hesitate and later turn back when the dark chamber was reached. Indeed, after a little training, the roach would resist attempts to shove it into the dark chamber. When the roach had made ten successive refusals to enter the dark chamber, the experiment was concluded for that day; to be repeated on the following and on a long series of successive days.

Szymanski (95) confined his experiments to larval male roaches of about the same age. Most of these were used in their normal condition; but from a few the antennae were amputated. Based upon their ability to form associations, Szymanski divides his roaches into three classes: (1) those that make rapid progress and fatigue slowly; (2) those that make rapid progress and fatigue rapidly, and (3) those that make slow progress and fatigue rapidly. Marked individual differences were noted in the length of time that they retained the acquired habit; but no relation was evident between the degree of permanency of the acquired habit and the number of shocks necessary to instill it. Although the training influences the creature for only a short time, the influence of it is latent. This is proven by the rapidity with which roaches that have once been trained relearn the habit. It is possible

to establish the habit in animals from which both antennae have been amputated.

Turner (97) experimented with adult roaches of both sexes, larvae of several different ages, and roaches from which the antennae had been amputated. This investigator agrees with the conclusions reported in the above paragraph and adds: "Generally speaking, male roaches learn more rapidly than female and young roaches are more apt than adults, but there are marked individual exceptions to this; roaches that have acquired the habit of refusing to enter a specific dark place do not lose that habit when they moult; during sickness and just prior to death, the retentiveness of the roach is much impaired." To test the meaning of this refusal to enter the dark chamber, Turner conducted the following experiment. A bottomless pen, containing one dark and one lighted chamber, was placed on a piece of white cardboard. A roach that had thoroughly learned to avoid the dark chamber and which had just been tested to see if the habit was well fixed, was placed in the lighted compartment of this pen. As soon as its meanderings brought it to the entrance of the dark room, it would enter. Immediately the roach was returned to the lighted compartment of the pen which was resting on the shocking board. In that pen it could not be induced, even by gently shoving it, to enter the dark section. After many repetitions of this experiment had demonstrated that normal roaches almost invariably react in this manner, the investigator concluded: "To my mind this test is a conclusive proof that the change in behavior of these insects is not due to a physiological reversal of the phototropic responses of the roaches, but a case of learning, by experience, to avoid a specific dark place because of certain disagreeable experiences connected with it."

By means of experiments, Wodsedalek (108) has been able to induce may-fly nymphs to form three new kinds of associations: (1) they were induced to increase the distance they would swim towards a stone, even when they must swim against the rays of light; (2) by means of rough handling, they were caused to exhibit fear (these fear reactions are discussed under "Emotions."), and, (3) by a method about to be described, they were trained to make new responses to food. Bits of algae were

presented to a nymph in forceps. After the insect had secured a hold, the forceps were gently withdrawn, thus inducing the nymph to follow. Later, a piece of alga was held near the nymph and, when the hungry creature attempted to secure the food, the forceps were gradually withdrawn. This caused the insect to follow the food. After being subjected for four weeks to such experimenting, many of the nymphs learned to swim considerable distances towards the food, and some would even swim towards the investigator if he made his appearance at one end of the aquarium when they were at the other. After two and a half months of such experience as soon as the experimenter appeared, the majority of the nymphs would swim towards him and claw against the side of the aquarium, and one nymph would even climb a stone and reach up into the air after food. Untrained nymphs never behaved in this manner. Wodsedalek feels that these three types of experiments demonstrate (1) that nymphs can be trained to respond positively to objects even in a lighted environment, (2) that they can learn gradually to inhibit their usual negative responses to light and proportionately reinforce their reaction to an object against the rays of light and in the presence of that object, and (3) that they can learn to associate the investigator's presence with food.

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LITERATURE FOR 1912 ON THE BEHAVIOR OF ANTS AND MYRMECOPHILES

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Miss Andries (1) made a detailed study of the taxonomy, biology and development of the German species of flies of the genus Microdon, which in their larval and pupal stages live in ant nests. The species studied (*M. rhenanus*, *mutabilis* and *eggeri*) live most commonly with species of Formica, though the forms of *eggeri* were found also with Lasius. Fertilized females of the fly readily oviposited on bark, inserting the ovipositor into cracks. About one hundred and fifty eggs are laid, five to eighteen in a lot. These hatch in about twelve days. The larvae are not unlike certain slugs, and in fact were described by some early writers as mollusks. They crawl slowly about in the nest, secreting from the mouth a fluid that keeps the under side of the body moist. The food habits are not understood. Andries thinks that they feed on the vegetable moisture in the nest, as no solid food was found in any of the specimens sectioned. The relationship of the fly in its different stages to the ants is not well understood. It was formerly supposed by Wasmann that the larvae were treated like big Coccidae. Those kept by Andries were entirely ignored by the ants, and it was noted that when nests in the field were disturbed the ants removed their brood to a place of safety, while the Microdon larvae remained behind unnoticed. Wasmann has observed the ants lick the golden hairs of freshly emerged adults, but Andries notes that the adults, both in the field and in observation nests, were treated inimically by the ants, which seized them by the legs and wings. She succeeded in bringing growing larvae through to the adult stage apart from ants, and does not believe that Microdon is closely dependent upon its host.

Brun (3), after numerous experiments on the colony forming habits of Formica, believes that the higher acervicolous species in the genus are descended not only morphologically, but also

biologically, from the *fusca* group, that is, from a *fusca*-like ancestor. In *fusca*, the habit of two or more queens jointly forming a colony—"pleometrosis" of Wasmann—sometimes occurs, but with this ant it is merely an occasional method of colony-formation. The typical method, according to which the individual female after the marriage flight starts her colony unaided, is most general. In *F. pratensis* and *F. rufa* pleometrosis is more fully developed, and is of use in splitting up the colony into branches, and by means of these extending the colony in the near vicinity. Brun considers that the great success of *rufa* as a species is accounted for by this habit of colony splitting. The origin of this branch-forming habit has been explained by Wasmann as an adaptation to special methods of life. *Rufa* and *pratensis* have become adapted to life in certain ecological situations, in which they are sporadically very abundant, in contrast to other more widely adaptable ants such as Lasius, Tetramorium, etc., which occur in nearly all kinds of localities. The special vegetative conditions to which *rufa* and *pratensis* are adapted are exhausted after the long residence of an ant colony in one place, and then it is beneficial to be able to split the colony, and enable it to spread in the immediate vicinity where the conditions are the same, rather than to send off swarms to less favorable localities. This branching can be accomplished by the raising of reserve queens, which produce branch nests for the excess workers. Each season, during the time of flight, large numbers of sexual forms are held back in the nest. This habit has gradually modified the normal instinct of the female, the mneme of which has thus been weakened ("büszt an Frische ein"). After the marriage flight the normal instinct of an ant queen is to dig a hidden chamber, but in *rufa*, whose ancestors were continually surrounded by workers, because of the inherited engrammes, there is developed a strong "social desire," which drives it to seek worker society. Here there are three possibilities. The female may return to one of the peripheral nests of the mother colony, becoming in reality parasitic on the members of her own colony, which is the first stage in social parasitism. Many do not reach their own colonies, but find other nests of the same species, or of another race and take up with them, while a comparatively small number, reaching *rufa*-free ground, enter the nests of strange species. This latter is the

last stage of social parasitism. It is thus shown that the social parasitism of *rufa* is derived from pleometrosis through a number of steps. That all of these intermediate stages occur in this species shows that *rufa* must still stand in a primitive condition as far as social parasitism is concerned. Wheeler has had a tendency to consider *rufa* as an obligatory social parasite (both Brun and Wasmann evidently fail to understand his position in regard to this matter), but Brun agrees with the theory of Wasmann, and furthermore endeavors to strengthen this view by an appeal to the engramme-theory of Semon, that pleometrosis necessarily causes degeneration and final loss of the colony-forming instinct, thereby giving a psychological foundation to the theory. From the standpoint also of paleontology, morphology and geographical distribution Wasmann's theory seems to be correct. Brun agrees with Wasmann also in considering that *F. sanguinea* approaches the *rufa* type biologically, and therefore has been derived from a *rufa*-like form. Emery, Viehmeyer and Wheeler, who have opposed Wasmann's theory and to some degree upset it, have maintained that, "A robber cannot be derived from a parasite," hence a robber ant, during its development, can never traverse the stage of social parasitism, even as a facultative one, as in *rufa*. They all look upon the pupal robbing habit as a distinctive mode of colony formation from which dulosis is supposed to have developed on one hand and social parasitism on the other, thus accepting the robber-female theory of Emery. As Wasmann himself has answered many of the attacks on his theory, Brun does not undertake to go into all of the criticism, but defends Wasmann on the ground that Viehmeyer must have misunderstood him. Wasmann never contended that the predatory stage of *sanguinea* is derived from a parasitic stage. The *sanguinea* group does not go back to *rufa*, but comes from a *rufa*-like form, which had a tendency toward pleometrosis and branch-colony formation, and thereby lost its ability to form independent colonies. From such ancestors there branched off a particularly viable race with high psycho-plastic tendencies, part of whose females, after the ancient manner, allow themselves to be taken up by the same species; others, "having higher attainments," since they could not accomplish this, took to robbing pupae, or made up to a colony founding *fusca* queen, which they later robbed or mur-

dered. Regarded in this way, the familiar statement that parasites cannot become robbers loses its significance as an argument against the derivation of *sanguinea* from *rufa*-like ancestors, for *sanguinea* comes not from *rufa*, but from a *rufa*-like type, with a loss of colony-foundation instincts, which does not involve parasitism. Neither does this mean degeneration, but rather a high development, as in the present day *rufa*. Viehmeyer's opinion that these species are doomed to extinction seems "curious" to Brun, considering the immense size of the colonies of *rufa;* as "curious" as the organic and psychical degeneration which he thinks he finds in the high psycho-plastic endowment of *sanguinea*. In saving the psycho-phylogeny of his robber stages, Viehmeyer assumes that the females of *sanguinea* originally took part in the robber raids of their colonies, but this opinion is too uncertain to be taken seriously in the discussion. Brun concedes Wasmann's derivation of dulosis in Formica from a facultative adaption stage to be the weakest part of his theory. The apparent analogy of permanent dulosis and temporary parasitic colony foundation will not stand strong criticism, because we do not know that the colonies are exclusively founded with the aid of *fusca*. We can account for the social parasitic condition of *rufa* only by assuming a condition involving the loss of the ability to establish a colony unaided, and this loss could have been due as directly to the pupal-robbing habit as to obligatory social parasitism. Wasmann did not mean that a subparasitic condition was a step toward dulosis, any more than he wished to deduce the already developed social parasitism from dulosis. He considers dulosis in *sanguinea* a direct engraphic influence. Through the presence of *fusca* in the nest the young *sanguineas* are influenced to raise the *fusca* pupae obtained by raids, and care only for those whose smell is similar to their own. This psychological reason of Wasmann does not seem to Brun to hold, for the tendency of *sanguinea* is not limited to *fusca* pupae, but extends also to allied species. This, Brun explains, is a fixed, inherited association from analogy. The workers in colonies not socially parasitic often show just as strong a tendency toward dulosis.

Brun is not inclined towards Wasmann's hypothesis of the origin of dulosis in *Formica* from facultative social parasitism,

but does lean toward his theory that the social parasitic stages were derived from a *rufa*-like form.

Brun (3) believes that the theory of the mixture of odors, which has been used to explain, in a purely physiological way, the tolerance of one species toward another in the artificial alliances of certain species of ants, must be given up, as entirely untenable. These artificial alliances do not depend upon the mixture of odor, but depend entirely upon complex associative brain processes, especially in the realm of individually acquired mnemic engrammes.

Cornetz (5) believes that the apparent coöperation of several ants in moving particles of food too large to be handled by a single individual is simply the result of the stimulus that causes the solitary ant to return home. When an ant starts on a foraging trip it receives, in some manner, an impression that later guides it back to the nest. When it finds a morsel of food it takes it, and returns by an almost direct route. Several ants, having hold of a morsel too large for a single one, are each guided by this direction-sense toward the nest, with the result that the combined efforts of many holding and pulling the piece of food are used to bear it. This gives at first sight the impression of mutual aid, but is in reality only "a fortuitous coincidence of purely individual actions." There is even actual hindrance to one another when many have hold of the same morsel. Likewise, other actions at first sight mutualistic are believed to be simply the result of individual activity or of a certain tendency toward imitation, comparable to the flocking of sheep. Thus, Cornetz saw an isolated worker digging at a new nest some distance away from the principal nest. In another instance seven workers were engaged in working at a gallery far from the nest. These carried eggs, larvae and even adults from the original formicary, in which, however, most of the colony remained. This division was in no sense beneficial to the entire community, but was probably the result of several workers following one that had started the new gallery. As the worker is merely an undeveloped female, the tendency to establish a new colony is not surprising, as often other female characters are more or less developed in individual workers, even parthogenetic reproduction, and the nest-forming habit is typically female. When one worker begins to dig a new nest, others coöperate

through imitation. Cornetz does not believe that the social coöperation of ants is altogether a result of individual action, but points out that there may be much less mutualism than is generally believed.

Cornetz (8) believes from a study of Myrmecocystus that this ant has, to a greater or less extent, an impression of the territory immediately surrounding the nest entrance, but that this memory is inconstant and of short duration, especially when based upon the visual sense. When the memory is olfactive it may persist for a long time.

Cornetz (10) compares the sense of direction of the rat and the ant. The rat observed by Szymanski (Essais pour exprimer par des nombres le rapport entre des stimulants de genres différents. *Archiv. f. d. ges. Physiol.*, Bonn, 1912) when liberated in a box containing a pan of water wandered about until it found this, but each succeeding time, by the "dropping of useless movements," shortened the distance traveled, till it finally went directly to the water. On each trip the rat had revived impressions that had been received on the previous trips. The ant, on the other hand, is guided by an impression received on each outgoing journey, and revived on the homegoing route. To what extent the ant is able to remember a direction "to the right" or "to the left" is still completely unknown, but Cornetz ventures the hypothesis that the ant does not need a memory, but possesses "en soi" a sense of direction. This he believes to be not at all impossible, though hard to conceive.

Cornetz (10a) experimented on the estimation of distance in ants. Workers of *Pheidole pallidula* away from the nest were decoyed by little pieces of cheese on to a knife blade, and taken to a point at a short distance away. When the ant dismounted from the blade it set out in a line parallel and opposite to the outgoing trail, reversing the direction of march in the manner usual to ants, but owing to the change of the starting point, not in the direction of the nest. Cornetz made careful comparison of the distance traveled on the wrong trail, and the distance to the nest if the ant had not been moved to another starting point. Where both trails were on the same kind of material, there was an error of from one-tenth to one-fifth of the distance, though one ant erred by three-fifths, which is an abnormal amount. When the trails were different (one on cement and the other on

bricks) the error ranged from one-sixth to nine-tenths of the distance. On a longer journey the error was still greater. The start in a direction the reverse of the line of march in the outward journey, even when not toward the nest, and on different kinds of material, offers additional evidence that the home-going ant is influenced little by sight or the sense of touch.

Cornetz (7) repeated the experiment of turning a disc on which an ant (*Myrmecocystus* (*Cataglyphis*) *bicolor*) was feeding. The disc in this case was a large plate, containing sugar as bait. Each time the ant, when it was through feeding and had a load of the food, immediately oriented itself in the direction toward its nest-entrance, though the disc had been turned 180 or 270°. The podometric sense, according to Cornetz, will not explain the return of the ant, both because "a podometer is no compass" and because the route taken by the returning insect is not the same as the outgoing trip. He answers the question, "How do ants find their way," by stating that they do not find their way. It is not necessary. They are guided by some internal impression received on the outgoing trip. Just what this is, he does not pretend to understand, but he believe that it is neither touch, smell nor sight, nor a combination of these, but something peculiar, possessed by all ants.

Crawley (11) studied parthenogenetic reproduction in *Lasius niger*, with colonies confined in artificial nests. It has long been known that under certain conditions, generally when no queen is present, worker ants are capable of laying unfertilized eggs that develop parthenogenetically. Some observers have concluded that only males are produced from these worker-laid eggs, but in 1902 a queenless colony of *Lasius niger*, kept under observation by Reichenbach, reared some three hundred workers and two or three dozen males from unfertilized eggs, and Wheeler in 1903 recorded similar results obtained by Mrs. Comstock with *Lasius niger* var. *americanus*. On the other hand, Janet, who made careful experiments with no less than thirty queenless colonies under varied conditions, succeeded only in getting males. Into a nest of *Lasius niger* that had lost its queen through accident, Crawley placed a queen of *Lasius umbratus* which was immediately adopted. Although this queen deposited many fertile eggs, for two years none of the young reached maturity, as they were eaten by the *niger* workers; thereafter the few

that did mature were immediately killed and eaten, or fed to the other larvae. During this time several hundred *niger* workers reached maturity. In another similarly composed colony the results were the same. During four years no males were produced. A third nest again containing a queen of *L. umbratus* and *niger* workers, with no brood at the start, produced only *niger* workers, normal in all respects except that they were somewhat undersized. Twelve workers were carefully dissected in order to ascertain if a receptaculum seminis was present. This was not found, so the experiment confirms that of Reichenbach and shows that in parthogenetic reproduction by worker ants, workers as well as males may result.

Crawley (12) found in England a colony of the parasitic ant *Anergates atratulus* in a *Tetramorium caespitum* nest. No sexual forms of the latter species were present. The male Anergates is wingless, and copulation takes place in the nest. The queens kept by Crawley removed their wings shortly after copulation, and made no attempt to leave the colony, but each queen seized a Tetramorium worker by the antennae and kept hold of it for hours. This habit may be useful in getting the queen into a strange nest, and may have for its object the acquisition of the odor of the Tetramorium. A colony of the latter ant that had adopted a newly fertilized Anergates queen, killed off all the sexual forms of its own species in the nest, including two dealated queens.

Donisthorpe (13) found colonies of *Leptothorax acervorum* and *Myrmica laevinodis* beneath the same stone. When the nest was disturbed they showed no antagonism toward each other, and if they picked up each other's larvae or pupae they put them down again. Small larvae of the fly *Microdon mutabilis* kept in an artificial nest with *Formica fusca* grew to a large size without being fed by the ants or feeding on the honey provided for them. When the ants moved, the Microdon followed them very slowly. It is evident that they feed on the droppings and pellets rejected from the buccal chamber of the ants. *Antennophorus uhlmanni*, which lives attached to *Lasius umbratus*, was observed to move to one side of the ant's head in order to permit it to feed.

Donisthorpe and Crawley (14) made a number of experiments on the founding of colonies by queens of *Lasius fuliginosus*. It

had long been supposed that this species was a temporary social parasite of *Lasius umbratus* and its varieties. A queen of the former species placed in *umbratus* colonies was not attacked at once, as is generally the case when a queen ant is introduced into a strange colony, but in some instances was attacked later on. When some part of her body was being held by an inimical worker, she endeavored to conciliate it by caressing with her antennae, and often succeeded. Some of the queens on which experiments were made were persistently molested and finally killed, but several were fully adopted and had larvae and pupae at the time the record of the experiment stopped. This shows that *fuliginosus* is a temporary social parasite of *umbratus*, which itself is parasitic in turn on *L. niger*. Several pupae of *niger* were placed in a nest of *umbratus*, in order to ascertain if the latter had any friendly instincts remaining toward the species in a colony of which it had begun its existence. The pupae were carried about; but were left too long before being opened so that most of the ants that emerged were crippled. These were bullied by the *umbratus*, but two perfectly healthy individuals were living in the nest, unmolested, at the time of writing.

Emery (15) observed that the eggs laid by workers of a harvesting ant, *Messor barbarus minor*, produced only males. The larvae were different in appearance from those which produced females and workers, so he concludes that sexual dimorphism is apparent also during larval stages. The same species was offered oats which had germinated and from which the husks had been removed. These were chewed by the ants till they became a ductile mass, from which the nutritive portions had been extracted. Dried oats, not germinated, were put in the nest. The ants ate first the embryo and the end of the grain where this was located, a habit that had been noticed by the ancients and which was mentioned by Plutarch. When the embryos and the farinaceous parts of the seed were separated and each ground up and made into a paste by the addition of water, the ants showed a decided preference for the paste made from the embryonic portion, especially when it was the more humid of the two. The cutting of the radicles of the seed by grain-storing ants may be the result of this fondness for the germinal portion. Italian paste in small ring-shaped pieces

which had been carefully weighed was placed before the ants in their nest, and the discarded refuse and pellets were afterwards weighed and a chemical analysis of the substance was made both before and after the ants had had access to it, so as to ascertain just what proportion of the total quantity and what nutritive properties of each had been consumed. Some of the paste was fed by the ants to their larvae after being softened by malaxation. The larvae ate this readily, so Emery decided that the making of "larval bread" as described by Neger, is not necessary. The workers consumed about 7.3% of the starch in the paste in order to digest it or give it as food to the larvae. The quantity of non-starchy foods was not ascertained, but Emery assumes that the nitrogenous portions are more important than starch.

The harvesting ants are descended from insectivorous forms, which have taken up the grain-storing habit as an adaptation to life in the desert, on steppes, etc., where during parts of the year insect food is scarce. Seeds can be stored and kept, which is not true of insect food. Emery notes that the species studied, though a typical harvesting ant, never refuses insect food.

Ernst (16) placed a number of queens of *Lasius flavus* in an artificial nest. Eggs laid by these developed rather slowly, but produced larvae and imagines. The latter, while yet callows, disappeared, and Ernst found portions of their bodies and in the same place two individuals of the mite, *Laelaps oöphilus*, which must have been introduced into the nest on the bodies of the females. The number of mites increased very rapidly till the bottom, sides and covers of the nest, twelve by nine cm. in dimensions, were swarming with them. Many were among the eggs and even crawled upon the ants' heads, from which they were dislodged by vigorous shaking. A living callow lying on the bottom of the nest was seen to be attacked by numerous mites, most of which were on the thorax and legs. The next morning only portions of the ant were found, the probability being that the mites had taken it to pieces, though this was not actually seen. The mites in the nest died off very suddenly, so observations could not be continued. Ernst, from a long series of observations, believes that ants are capable of forming attachments to one another. Though an ant recognizes and is friendly

to others of the same colony it does not generally associate with one particular individual more than with others, but Ernst observed that two isolated ants showed an attraction for each other, remaining together much of the time, and when one died the other showed signs of much uneasiness. In the case of two females and a worker of *Tapinoma erraticum* which were kept isolated, the former seemed much disturbed at the death of the latter, licking and feeling of the body. These actions were more pronounced in one of the females than in the other. A female of *Formica rufibarbis*, after killing two females of *F. pratensis*, received a third without signs of hostility, and the two lived amicably together. Different species of ants vary in their aptitude for making friends, and the females form the association more quickly than the males. Ernst observed a Dipteron, *Farnia manicata*, in company with ants, in the act of "milking" aphids and sipping up the drop of exuded liquid. The fly stroked the gaster of the aphid with its forefeet, which are provided with a brush of hairs.

Besides ants and this interesting dipteron, a Lycaenid butterfly in Ceylon is known to milk aphids.

Hungerford and Williams (17) in Kansas observed that the great majority of nests of *Pogonomyrmex occidentalis* have their openings on the southeast side or more toward the east. A heliotropic influence is suggested.

A special disgust was shown by the workers toward certain Scaraboeid beetles. When one of these was placed on the nest it was attacked by as many as ten workers, and when it had ceased struggling was carried to a distance of ten or twelve feet from the cone. The ant was seen carrying the myrmecophilous beetle *Cremastocheilus saucius*.

Hunter (18) notes that in fields infested with the agricultural ant, *Pogonomyrmex barbatus* var. *molefaciens*, the plants in a circle just outside the cleared areas of the nest grow with increased luxuriance, a condition he thinks, caused by the loosening of the soil through the underground tunnels of the ants, which has somewhat the effect of deep plowing. This increased growth is, in a way, compensatory for the cleared areas which the ants make, and though it does not entirely offset the loss caused by them, reduces the economic importance of the insect.

The actual damage caused by these ants is said by Mr. J. D. Mitchell, who has made many observations on the species, to be greatly overestimated.

Von Ihering (19) in Brazil found nests of the army ant, *Eciton coecum*, deep in the earth beneath termite nests. It has long been supposed that ants of the genus Eciton do not make permanent nests, but move about from place to place. At times clusters have been found with many workers, larvae and pupae, and often a female, and these have been considered temporary nests. Von Ihering thinks that these are swarms. The female, blind and wingless, is not capable of founding a colony unaided, after the manner of most queen ants, and new colonies are established by means of a "swarm," composed of a queen and numerous workers, often accompanied by males. Sometimes males of different species are present, and von Ihering thinks that hybridization may not be uncommon among the species of Eciton.

Jacobson (20) in Java observed the larvae of the butterfly, *Hypolycaena erylus*, which is attended by the ant *Oecophylla smaragdina*. Both of these insects were common on the rubiaceous plant *Banguersia spinosa*. The butterfly lays her eggs on a plant tenanted by the ants. These attend the larva, and by caressing it receive a drop of exuded liquid which is eagerly lapped up. A considerable amount of this liquid is secreted by a single larva during the course of a day. Larvae under observation, not attended by ants, became listless and later died, so there is evidently a close though not well understood, symbiotic relation between the two insects. The pupae also were cared for and licked, though in them there is no evident food supply for the ants.

Lea (21) in a supplement to a paper on the Australian and Tasmanian Coleoptera inhabiting or resorting to the nests of ants, bees and termites (Proc. Roy. Soc. Victoria, Vol. XXIII, (New Series, pt. 1, 1910.)) lists and describes a large number of myrmecophilous and termitophilous beetles. Through the energies of Mr. Lea and his co-workers the very rich ant-nest fauna of Australia and Tasmania is becoming comparatively well known. It is an interesting fact that the ponerine ants of those islands, especially *Ectatoma metallicum*, harbor a preponderant number of the inquilines.

Leonard (22) observed workers of *Messor andrei* after a heavy rain carrying out members of the colony which were covered with mud and quite lethargic. After these had remained in the warm sunshine for a time they returned into the nest. Leonard assumes that they had suffered from the wetting and the nest-mates had carried them out where they might revive.

Lucas (23) notes that in a colony composed of about twenty workers, without a queen, of *Formica fusca* in an artificial nest, eggs were deposited parthogenetically. These were either eaten or neglected by the ants, so none developed.

Malloch (25) in a monographic revision of the dipterous family Phoridae lists sixteen North American species that are known to be associated with ants. Most of these are parasitic, though one species, *Metopina pachycondylae*, is known to live as a commensal with *Pachycondyla harpax* in Texas.

Mann (26) observed the Proctutrypid *Mimopria ecitonophila*, with *Eciton hamatum*, the host ant. The parasite runs along with the army of workers in an ant-like manner, and is sometimes picked up and carried by the ecitons.

Mann (27) found in Brazil a Ponerine ant, *Odontomachus affinus* subsp. *mayi*, living in company with *Dolichoderus debilis* var. *rufescens*, in an arboreal earthy nest constructed by the latter species. Odontomachus generally nests in damp places such as beneath stones or logs. In the earthy nest of Dolichoderus this variety finds a suitable arboreal environment, and being a powerful, stinging ant, is very probably useful to the Dolichoderus in defending the nest.

Newcomer (28) in California studied the caterpillars of *Lycaena fulla* and *L. pseudargiolus* var. *piasus* in their relation to ants. The latter species in the third and fourth instars is very generally attended by *Tapinoma sessile* and *Prenolepis imparis* and occasionally by Crematogaster and Camponotus. An ant, on discovering a larva, proceeds to stroke its posterior segments with the antennae, and to feel about with its palpi. If the ant touches the evaginable organs of the eleventh segment it immediately becomes greatly excited and runs about as though irritated. The sharp projections on the setae of these organs evidently irritate the sensitive antennae, and thus act as a repellant when the caterpillar is not able to exude the liquid which the ant desires. A caterpillar may be disturbed several

times by the ant before the slit on the tenth segment opens and the papilla which bears the drop of liquid is thrust out. The ant laps this up, while it is stroking the larva with its antennae. *L. piasus* emits a drop of the liquid about once every fifteen minutes. The stroking of the larva by the ants acts as a stimulus which causes either the ejection of the liquid or, in case the organs are not in a condition to exude, the eversion of the repellant organs of the eleventh segment.

Piéron (29) gives a general survey of the observations and experiments by various investigators on the problem of orientation in ants. As far back as 1745, when Bonnet published on the subject, it has been known that the sense of smell plays an important rôle in guiding the ant back to its nest. Huber, Forel, Bethe and others have confirmed this, till there is no doubt as to its truth, and Santschi has recently shown that certain species by means of touching the ground with the tip of the gaster actually make an odoriferous "intentional" trail. The differences in this trail, which naturally varies in intensity close to and remote from the nest, are appreciated by the "topochemic sense" (Forel) and are therefore valuable in orienting the home-going ant. Odor plays a more important rôle with those ants which have a collective trail, except in some forms, like the wandering Ecitons and the slave-making Polyergus, the armies of which do not return directly by the outgoing trail. In the case of isolated foraging ants, in the environs of the nest, it is probable that sight, smell and touch are all employed, different forms of ants varying in the degree in which these various senses are used. Thus Lasius is considered by Piéron to be an olfactive type, Formica and Camponotus visual types and Messor a muscular type. Orientation at a distance from the nest opening has been explained in a number of ways, and it is probable that the muscular memory and the influence of the light are both important elements, though neither fully explains the problem. The ant does not exactly retrace its steps and probably makes more movements on the out-going than on the returning trip, which may cause considerable error in locating the nest again, while the impression given by the light is obviously received only by diurnal species. Piéron points out that the agricultural ants—Messor—of Erytrea stop

foraging at the close of the day, and asks if this could be caused by the need of the direct influence of the light for guidance.

In addition to light and the muscular memory there must be some other influence. Two hypotheses are suggested. Either the ant possesses a magnetic sense, or there is some internal organ that records sensations made in describing angles on the outgoing trail.

Ruschkamp (31) found in Holland the first stage of an adoption-colony of *Formica rufa* by *F. fusca*. A single deälated *rufa* queen was in a nest occupied by a weak *fusca* colony. No *fusca* queen was present. This mixed colony was placed in an artificial nest and observed for some time. The alien queen had been completely adopted.

Wasmann (32) describes an extraordinary Staphylinid beetle, found in West Africa with the army ant, *Dorylus* (*Annoma*) *nigricans* subsp. *sjostedti*. This beetle, named *Mimanomma spectrum*, is a most striking example of mimicry, with greatly elongated thorax, short, thick antennae and ant-like abdomen. The latter has the first two segments small and constricted, resembling in form the petiole and post-petiole of Annoma, and the general form of the body is more ant-like than even the Staphylinid *Mimeciton pulex*, hitherto the most remarkable ant mimic among the beetles. A number of species of the family Staphylinidae are exceedingly similar in form to the ants with which they live; also some of the parasitic Hymenoptera and even Diptera which live with ants resemble them closely, but none are so greatly modified as this new species described by Wasmann.

Wasmann (33) gives a list of some forty species of inquilines recorded from the nests of one species of ant, *Solenopsis geminata*. These represent the orders Coleoptera, Diptera, Hymenoptera, Thysanura, Acarinae and Diplopoda. A number of guests of East Indian species of Pheidole are listed also, and several new species of myrmecophilous Coleoptera are described.

Wasmann considers that the adaptations to myrmecophily in the European lady-beetle, *Coccinella distincta*, present a Darwinian paradox. The larva of this beetle lives unmolested in the nests of species of Camponotus and Formica, where it feeds on scale insects which are fostered by the ants and from which

the ants receive part of their food supply, and is therefore inimical to the welfare of the ant community. Such an association, Wasmann thinks, could not have been brought about by natural selection. That selection is a factor in evolution is admitted, but it does not play a leading rôle.

Wheeler (34) describes a peculiar coenobiotic association which he found in Arizona. Five or six organisms coöperate to form this. The oak, common in the Huachuca Mountains, was heavily infested with the mistletoe. Larvae of a weevil had made their borings in this, and these were tenanted by colonies of the ant *Cremastogaster arzionensis*. On the inside of the ant galleries were numerous scale insects, later described by Cockerell as *Pseudococcus phoradnedri*, which slowly kill the mistletoe. Thus the ant, which fosters scales injurious to the mistletoe which is a serious parasite of the live oaks and other trees, may be regarded as a useful forest insect.

Zimmer (35) records the finding of a nest of *Lasius fuliginosus* in a child's coffin which had been buried for about thirty years. The entire interior of the coffin was filled with carton made by the ants.

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LITERATURE FOR 1912 ON THE BEHAVIOR OF VERTEBRATES

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VISION

Fish. Loeb (16) discusses briefly the problem of color and pattern adaptation in the flat-fish. He is inclined to accept the suggestion of Munk and Henschen that in vision there is formed an image, not only upon the retina, but also upon the cortex, and to develop such a view even farther. Taking as a foundation the work of Sumner in which it was shown that the flounder was able to reproduce rather complicated patterns upon its skin, Loeb assumes a point for point correspondence between the retinal image and the pattern formed upon the skin. The mechanism of this process is expressed in two sentences:—"Es liegt nahe, anzunehmen, dass jeder Punkt des Retinabildes ein Reizpunkt ist, welcher einen entsprechenden Bildpunkt durch Vermittlung einer Nervenfaser in den primären Optikusganglien hervorruft. Jeder Bildpunkt in den primären Optikusganglien kann wieder als Reizpunkt angesehen werden, der durch Vermittlung einer besonderen Nervenfaser eine einzelne Cromatophore der Haut oder eine kleine Gruppe derselben in einem bestimmten Sinne beeinflusst." While such an explanation may prove useful by suggesting experimental procedure, the supporting evidence advanced is too meagre to give it value save as a working hypothesis.

Goldsmith (7½) reports further experiments upon *visual memory* in fish, claiming to have confirmed with three other species, her results of 1905.

New objects always frighten Gobius and Gasterosteus, but once having received food from forceps, the fish readily return, although still shy of a new object. She concludes that these fish retain "the memory of the aspect of objects along with that of their topographical situation."

Color experiments were carried on in two ways. 1. Colored papers were used on the bottom and sides of a glass basin.

* With the assistance of Ruth J. Stocking and Helen B. Hubbert.

Gobius show at first, as do the fish in Bauer's experiment, an aversion to the red, refusing to pass through the red passage-way which they traversed freely while the bottom was sanded. After one hour, however, they make no discrimination. With Gasterosteus red was always "chosen" in preference to any other color; yellow, green and blue followed in order. Instead of indicating, as Mlle. Goldsmith claims, ability to distinguish *colors*, it would seem that the basis of discrimination is that of *brightness difference*, as has previously been pointed out by Hess.

2. Food was given from different colored forceps. The fish returned to the food-carrying forceps (the red) except when they were exactly transposed with the empty blue forceps. Then they came to the place where the red had been. The conclusion of Mlle. Goldsmith is that they have a *memory for colors*, as well as for position. The former is feeble and when memory of color and position conflict, the memory of place prevails.

The author found that the young of *Pleuronectes* were quite "curious" as to new objects. She accordingly took a record of the time necessary so to accustom them to a new object that they no longer noticed it. The time was not kept with exactness. Indeed, all through the experiment there is a deplorable lack of technique. Memory of color is claimed to have endured twenty-eight days, *i.e.*, twenty-eight days after having received food from the red forceps, one individual went directly to them on immersion of the red and blue forceps.

M. Piéron, in a discussion of the work of Mlle. Goldsmith, shows that "numerical precision" should have been sought as to the rapidity of the vanishing of the mnemonic trace, and also calls attention to the necessity of excluding from color experiments the luminosity variant. The lack of careful standardization of experimental conditions deprives the author's results of the value they otherwise might have. The paper deals as much with the formation and retention of habits as with vision proper.

Birds. Breed (2) shows that chicks in advance of any training respond positively to the more intense of two non-chromatic light stimuli. A similar result was not found in the case of chromatic light stimuli. Breed holds that this points to one

or both of the following conclusions: that (1) a difference exists between the chromatic luminosity values for the chick and those for the human being; or (2) the chick exhibits a qualitatively determined preference such as is apparent in some other animals. From results which the reviewer has in his hands, it is perfectly clear that Breed's first contention is contrary to fact, the chick's luminosity curve for monochromatic light being almost entirely similar to that of the human being. Whether we are forced to accept the second part of his conclusion depends upon the extent to which Breed and others have brought out all the remaining facts in the case.

The author finds further that chicks are able to select one of two colors at the brightness indifference point.

One of the animals gave convincing evidence of ability to make the circle-square distinction, while another animal quickly acquired the small-large habit—two circles eight cm. and five cm. in diameter respectively were used.

Mammals. Vincent (26) has given a very valuable table showing anatomical features of the mammalian retina. It is compiled from various researches dealing with the presence or absence of rods and cones, their relative number, distribution, the nature of the fovea and sensitive area, refraction, stereoscopic vision, etc.

Hoge and Stocking (12) in their study of motives have shown that the albino rat and hooded black and white rats can form a habit of responding positively to one of two white lights (when the intensity of one was two c. p., and the other sixteen c. p.). The number of trials required for the formation of this habit varied with the motive used, one animal requiring 490 trials, two others completing at the end of about 550. The authors show that in the discrimination of these lights, the offering of food with success and punishment (electric shock) with failure is more advantageous than the giving of either food alone or punishment alone.

Lashley (15) made a long series of tests upon albino rats to test their sensitivity to difference in form and size. In the first place he found that the introduction of a slowly moving sector in the pathway of one of the light stimuli produced no hastening of the habit of discrimination. He was enabled to get one animal to discriminate between vertical and horizontal

lines, and another to discriminate the thirty mm. from the fifty mm. circle. In testing for the threshold of form discrimination he found that one animal probably distinguished between two rectangles of twenty by thirty mm. with their long axes respectively horizontal and vertical, although forms more widely different (square and circle) were not distinguished.

Washburn and Abbott (28) in a carefully controlled research show that the rabbit can discriminate between the Bradley saturated red paper and Hering's grey Nos. 7, 14 and 15. Care was used to show that the discrimination was made in visual terms. Red was found to have a distinctly low stimulating effect. One series of experiments show discrimination between Hering's velvet black and Bradley saturated red, although some experiments carried out to test this latter conclusion fail to confirm the first set of experiments. The authors do not maintain that the above discriminations were made on any other basis than that of brightness difference.

The results obtained with saturated blue are not decisive; the animals, though, regularly distinguished it from Stoelting black. Here, too, the discrimination was probably made in terms of brightness. Several experiments tend to show that the brightness equivalent of the blue probably lies around Hering's grey No. 7. The authors hold that they have obtained some evidence to show that the rabbit is able to form the habit of choosing the darker of two impressions, irrespective of their absolute brightness. It is probable that the rabbit, while capable of using binocular vision, uses monocular more commonly.

Smith (24) tested the color responses of dogs. The tests were carried through completely only on one dog. The apparatus consisted of a large box suitably divided into home and trial compartments. Five shutters, each of which when pulled upward disclosed an opening for the exit of the animal, carried the stimulus. Food and punishment (consisting of electric shocks) were used as motives.

The principal stimuli employed were the Zimmermann colored papers; the most saturated red, blue, green, yellow, magenta and orange (Nos. c, o, k, g, a). The color work was controlled by the use of achromatic stimuli. For this latter work Nendel's greys were employed.

The author concludes that while certain of the dogs do pos-

sess the power to make rudimentary distinctions between the color, this function is a highly unstable one and cannot be supposed to play a part in the normal life of the dog. Furthermore, even when discrimination among the colors has been established, it may be lost easily through differences in luminosity and position.

AUDITION

Mammals. Shepard (22) finds that the cat discriminates articulate sounds, responding to its own name. The experimenter was in plain sight of the animal during the entire time of observation, sitting about a meter away in front of the cage. He worked with two cats. The name-reaction demanded in one case was the rearing up of the animal against the cage; while in the other case "the animal looked toward the food when its name was called." Learning in the latter case was considered as attained when the cat responded in this way to its name nineteen times out of twenty, and to "no feed," the counter phrase he used, four times out of twenty.

Swift (25) reports some experiments upon a dog trained to take meat at a low tone and to refrain from taking it at a high tone. After training, the left temporal lobe was removed; training was then resumed and when the reactions were reestablished, the right temporal lobe was removed. The author reports that even after both lobes have been removed the dog can be retrained (slowly) to distinguish between the two tones used in the original training and also to establish new associations.

It is very doubtful if any of the work recently reported by Kalischer and by Swift will bear critical scientific examination. Johnson, in a recent monograph (*Behavior Monograph No.* 8) discusses their experiments at length. The reader is referred to this place for critical evaluation of such studies.

Johnson (14), in a review of Oscar Pfungst's report, "Der sprechende Hund," accepts Pfungst's explanation of the claims made by the dog's owners. The animal was reported to possess a vocabulary of eight words; *Don*, *Hunger*, *Haben*, *Kuchen*, *Ruhe*, *Ja*, *Nein*, and *Haberland*, and with these words to answer accurately certain questions as, "*Was hast du?*" "*Hunger.*"

Doctor Pfungst with Professor Vasseler and Doctor Erich Fischer investigated the behavior of the animal, a German

setter seven years old, and found, first, that his vocabulary consisted of just three sounds: one vowel, of a value lying between *o* and *u*; one guttural-aspirant like the German *ch*; and one nasal, lying between *n* and *ng*. A sound made by the dog, expressed by *ch-u-ng-uo*, is easily interpreted by suggestible hearers as "*Hunger*." They also discovered that he always responded, with the various combinations of these sounds that he used, in the same order, beginning with "*Don*" and ending with "*Ruhe*" no matter in what order the questions were put to him, so that he might desire "*Hunger*" be called "*Kuchen*" and so on.

Doctor Pfungst concludes that the speech of Don is to be regarded properly as the reproduction of vocal sounds which produce illusions in the uncritical hearer, who makes no effort to distinguish between perception and imagination and ignores the rôle played by imagination. Johnson adds that, "we may expect animal lovers to continue to read their own mental processes into the behavior of their pets," and "scientists of a certain class to continue * * * to proclaim * * * that they have * * * demonstrated the presence in lower animals of intelligent imitation and other extremely complicated mental processes."

CUTANEOUS SENSITIVITY

Amphibia. Babák (1) has devised a very sensitive method of studying the sensitivity of the frog to various stimuli. He has found that the breathing rhythm of a frog with the fore-brain removed proceeds with machine-like regularity, interrupted only when the animal is stimulated and resumed shortly after the stimulating agent is removed. In the maimed frog lung ventilation also occurs only after stimulation. In his first paper upon the sensitivity of the frog, the second of a series of studies upon the breathing rhythm, the author takes up the sensitivity of the animal to temperature as determined by changes in the breathing rate. The animals used were completely recovered from the shock resulting from operation upon the brain. The temperature stimuli were applied by means of a thermaesthesiometer held at a distance of one mm. from the animal's skin. The actual temperature changes in the skin could be judged only approximately. During experimentation great care was required to avoid auditory and tactile stimuli, etc.

The specimens studied were found to be sensitive to slight changes in either direction from the physiological zero point. No means of measuring these changes were found, but the same stimuli were applied to human subjects, and this leads to the conclusion that the frog's skin is at least as sensitive to temperature as that of man. The head was found to be more sensitive than the sacral and lumbar regions.

Stimulation with a temperature above the physiological zero caused an increase in the rate of breathing, with one below a decrease. This was not explainable as a change in physiological rate due directly to change in the temperature of the organ systems, since the change in temperature affected only a small area of the skin. Hence the author concludes that there is no direct energetic relation between the direction of change in the stimulus and the direction of change in the reaction. Moreover, all temperature stimuli caused lung ventilation, reactions in the same sense or direction. In spite of this last fact and the morphological results of the investigation of the temperature sense in man, the author is inclined to support the old assimilation and dissimilation theory of Hering as furnishing the best explanation of the difference in the sense of reaction. He asks "Wurde es vielleicht allgemein gelten, dass eine jede noch so kleine Energiezufuhr in das System eine Beschleunigung, eine jede Energieausfuhr eine Herabsetzung des Atemrhythmus bewirkt?"

Fish. Parker (18) reports a series of experiments upon the common chemical sense of Ammocoetes and of Amiurus and considers the structural and phylogenetic relations of this sense to those of smell and taste. He finds that the skin of Ammocoetes is sensitive to HCl, NaOH, NaCl, and quinine in solution, but not to cane sugar. The solutions were brought in contact with the skin by means of a pipette and their effect judged by the animal's movements. Three regions of the body were studied, the head, the mid-trunk, and the tail. The head was found to be far more sensitive than the tail and the latter somewhat more sensitive than the trunk. Experiments with Amiurus gave essentially the same results but with no difference in sensitivity between the mid-trunk and tail. Sectioning of the olfactory crura did not affect the reaction, nor was the sensitivity destroyed by severing the lateral line nerves and lateral accessories. This limits the sensory

mechanism to the terminations of the spinal nerves in the epidermis and assures that the common sense is independent of the taste buds which are scattered over the surface of the body and are innervated by the lateral accessories.

By an examination of the effects of various substances Parker concludes that the ions stimulating the common chemical receptors are the same as those stimulating the human taste buds, and that taste and the common chemical sense are closely related in the vertebrate both with respect to their sensitivity and the nature of the stimuli received. Smell, on the contrary, he finds in fish, as in the land vertebrates, to be much more sensitive to weak stimuli, and to serve, probably, as a distance receptor.

The author differs from Herrick and Sheldon in holding that the olfactory sense presents the primitive form from which the others have been derived. He is led to this view chiefly by the similarity of the olfactory neurone to sensory cells found in invertebrates.

In a brief preliminary note Shelford and Allee (21) describe their apparatus for the study of reactions of fish to solutions of gases and solids and review the results obtained by its use. The device consists of a rectangular tank with an intake at each end and an outlet in the middle. Waters differing in their dissolved contents can be admitted at the two ends, thus forming, in the middle of the tank, a gradient to which the fish react. Eight species of fish were studied. They were found to give indefinite or slightly negative reactions to changes in oxygen pressure and to slight reductions in the salt content. There was no evidence of reaction to nitrogen. All the fishes avoided water containing a per cent. of carbon dioxide greater than that to which they were accustomed (to increases of from five to sixty cc. per liter), and when an increase in carbon dioxide was accompanied by a decrease in oxygen the negative reactions became very pronounced.

The authors conclude that, except in cases of strongly alkaline waters, the content of carbon dioxide furnishes the best single index to the suitability of a water for fishes. The experiments seem to have been well controlled by the use of a second tank in which only one quality of water was used.

EXPERIMENTAL AND OBSERVATIONAL STUDY OF INSTINCTS

Amphibia. Hargitt (10) gives some interesting data upon food taking and hibernation in two species of tree frogs (*Hyla versicolor* and *H. arborea*). In regard to food taking he says it is evident that the tree frog responds only to moving objects. A motionless spider may remain for hours in the cage without being disturbed; the moment it becomes active, however, the frog will seize it. The frog usually leaps to take its prey, rarely stalking it. It waits until the prey is within leaping distance, which may mean several feet. It springs upon the victim, taking it with ease and rarely missing. Its prey apparently is not seen at close range.

In regard to hibernation the author says that the laboratory specimens show no tendency to hibernate so long as normal temperature is maintained. Several specimens were taken into a cool, damp cellar, the last week of December. Very soon after the change they showed signs of dormancy and burrowed (this consists of *backing*, using the hind feet and sharp posterior end of the body) under the mass of debris. The experiment upon hibernation was not completed because of the death of the animals.

In regard to color changes, it may be said that there is a wide variation in the native habitat even where the environmental conditions, so far as could be observed, are the same. Experiments show that, as a rule, light tends to bleach the skin and rob it of its pattern. Darkness seems to have no positive effect upon the color change or skin pattern. Some exceptions to the lightening effect upon the skin of light are to be found. In some cases a greenish color was induced by sunlight which persisted for days. High temperature seems to act much as does strong light—in general producing lightening of the skin. There are also some exceptions to this rule. A low temperature seems to have no effect upon color change. Contact stimuli seems to be equally void of effect upon color change.

Reptiles. Ruthven (20) makes some interesting observations on the breeding habits of Butler's garter snake (*Thamnopsis butleri Cope*). He concludes that the breeding season is about a month long, its initiation depending on the climate, being in Southern Michigan from the latter part of March over most of April. In the case observed by him courtship lasted for five days, copu-

lation for two hours and fifteen minutes, beginning about noon, and the period of gestation was 144 days long.

He also concludes that the so-called snake piles are due to the sexual impulse and not to the social, for when the sex impulse was at its height in the case observed, five males were at the one time endeavoring to copulate with one female.

Birds. Haggerty (9) presents a clear case of the first performance of a particular instinctive act of a young bird. A young sparrow hawk, having fallen from its nest with injury to its wing, was removed to the laboratory and reared by hand. It throve and became very gentle. On the third day a small piece of roast beef was placed in the cage; the hawk seized the meat with one foot, sinking its claws viciously into it. Its feathers became ruffled and its wings outspread. It fluttered about the cage, still holding to the meat. It continued for some time to strike its booty with its bill, the free foot and its wings. Apparently the larger the piece of meat and the greater the hunger of the bird, the more pronounced was the reaction.

Craig (7) shows that the blond ring-dove (*Turtus risorius*) does not instinctively give drinking response to the sight or sound of water nor to the touch of water on distal parts of the body. The young dove first gets its bill in the water by pecking at objects in the water. The contact of the fluid on the skin inside the mouth releases the further steps of the act of drinking. Birds will imitate pecking of parents or other birds, but do not imitate the act of drinking as such.

The same writer (6) has made observations upon the manner in which young birds break out of the egg. The results of these observations confirm those obtained by the early naturalists. The author summarizes these as follows. The bird chips the egg a little at a time with the bill; as it does so it turns around inside the shell, the axis of rotation coinciding with the long axis of the shell. As a consequence of this form of action, the egg is chipped around the large end in almost a perfect circle. After the circle has been almost or quite completed, the bird pushes in such a way as to force apart the two sections of the shell.

Phillips (19) gives the results of some observations on the inheritance of wildness in "English mallards," a game bird long bred on the English preserves. Young ducks of pure

strain were hatched under hens. These ducklings were found to be quite tame from the first and as easy to manage and rear as the common duck. Their instincts, however, especially those of feeding, differed widely from those of the common duck. On the other hand, the young of back crosses between the common tame mallards and pure wild black ducks (*Anas tristis*) gave other results. One such cross gave young which showed three-quarters *A. tristis*, while in two other crosses the young were only one-fourth *A. tristis*. The three-quarter *A. tristis* showed exceeding wildness. They were hard to manage and were reared with difficulty, but their dispositions changed with age and they became much more like ordinary ducks.

Mammals. Slonaker (23) undertakes to give some expression of the normal activity of the albino rat from birth to death. In studying normal activity at different ages he used a cylindrical cage which revolved upon a stationary axle. On the axle were fastened the nest box, the food box, and the drinking pan. These parts were arranged in such a way that the animal had to step to the floor of the revolving cage in order to pass from the food or water receptacle and vice versa. The weight of the animal caused the cage to revolve whenever he stepped upon the inner surface of the cage. A recording device was installed which indicated the number of revolutions made by the cage and their temporal distribution. Eight young rats were kept with the mother until twenty-eight days of age. Four were placed in the apparatus described above, where they remained constantly, except for weighing and cleaning of the cages, etc., until death. A separate revolving cage was provided for each animal. The other four rats were used as controls. They were placed in separate stationary living cages of the ordinary variety. Several important results are claimed for this research. The daily activity increases rapidly during the first third of the life period, after which there is a gradual decrease until death. During the period of youth and that of old age, the active moments are well distributed over the whole twenty-four hours, whereas, during the prime of life, activity is confined principally to night and rest to day. The rats are thus nocturnal. In regard to the amount of work done, it was found that three-fourths of the total amount done was done before middle age was reached. During the last thirty per cent. of life, only one-

eighth of the total work was performed, whereas, during the first thirty per cent. of the life span, three-eighths of the total work was done.

Unexercised animals (controls) reached their maximum weight at an early period. At corresponding ages the controls had a greater absolute weight than the exercised rats. The unexercised animals lived longer than the exercised ones.

Slonaker's conclusions probably have not the universality he claims for them. In the first place, the activity necessary to cause the cage to revolve cannot be taken as an index of all other forms of activity. Probably many other forms of activity have a far different type of life history than that involved in causing the cage to revolve. Further, Slonaker's work tells us really nothing of the relative amounts of work the animals can do at different ages. This phase of the subject is not touched upon by him. He sets the adult rat to revolving a mechanism so delicate that a twenty-eight days old animal can work it. His records show not the amount of work the animal can do at different ages, nor even the relative lengths of time during which this activity would take place under slightly different conditions. In other words, Slonaker is dealing rather with the temporal aspects of a certain type of activity. Often the distribution of time in running is misleading, too, because of the unequal effort called forth between young and old. The rat at twenty-eight days is probably working up very near to his maximum limit of effort in causing the cage to turn; he may leave off at any time by reason of exhaustion; whereas the adult rat may cease activity at the end of two hours merely because a stronger stimulus impels him elsewhere. It seems to the reviewer to be hard to draw any legitimate conclusion from Slonaker's work until there can be some suitable method of getting a measure of fatigue, etc.

Coburn (3) records some specimens of the house mouse (*Mus musculus*) which were able to sing in the sense in which that act has been described by Lee and Brehm. The "singing" resembles the soft chirp of a bird; it is best described as a rapid, whole toned trill involving the tones of c and d. The clang character is similar to that of flute or pipe tones.

Cole (4) summarizes his observations on the instincts of raccoons and their use of the senses. He gives the following as

a partial list of the more important instincts. Certain *vocalizations*, such as the whimper and the purr; *sucking*, which is active until the young are four months old; *creeping; climbing*, the latter beginning to appear at a very early age. At one month of age it is able to sustain its own weight with one paw by clinging to a support; in this instinctive attitude it is difficult to remove the young animal from bushes, etc. *Playing*, with parts of its own body; rolling a small object between the forepaws; engaging in mock combat; pretence of biting the hand, etc. *Following; fear; anger; curiosity; dipping food in water;* the sex group does not appear until the twelfth month.

In drinking they lap water or milk with the mouth close to the fluid. When heated, they pant much like dogs, with tongue slightly protruded. In sleep, one position assumed is that of lying on the back with the fore paws over the eyes; another is rolling the body into a ball with the top of the head placed flat on the floor between the forepaws.

ORIENTATION

Birds. Ménégaux (17) proposes to study the migrations of the European quail in order to determine the route of migration and the winter feeding grounds. It is known that the birds cross the Mediterranean and arrive in Morocco, Algeria, Tunis and Tripoli in autumn, but beyond this there is little definite knowledge of their movements. The experiment planned will involve the banding of 500 birds in France for the study of the autumn France-to-Africa migration; of 500 in Algeria and Tunis for the route of return to France; and, finally, of 500 in Egypt to determine whether the Egyptian birds return to France or go into Asia Minor and the region of the lower Danube. The author expects that the twelve and a half per cent. of returns usually obtained from marked birds will give sufficient data to establish the lines of migration and the regions in which it will be necessary to protect the quail in order to maintain the supply in France. While this work is undertaken chiefly from the point of view of economic zoölogy, it may furnish data upon orientation of interest to the student of behavior.

Mammals. Cornetz (5) compares the method of orientation in the ant and the rat. He considers first an experiment of

Szymanski's in which a rat learned a very simple maze in five trials, shortening its path somewhat at each trial. His analysis of this experiment is something of a mental atavism. The rat was trained to run through the maze to a dish of water, and Cornetz, after describing the first two trials of the experiment, proceeds as follows: "He (the rat) thus recognizes that the water dish is a little to the left (of the entrance to the maze); yet I do not feel the need of supposing that he wished to suppress the useless movements of his former path." After the rat has made two more trials:—"Now the rat has grasped the position of the water dish in space much more clearly, confirming the path of the third trial by that of the fourth, and is able to go directly to the water. It is not, it seems to me, for the useful purpose of reaching the water dish more quickly that the rat shortens his fifth path but because his representation (conscious?) of the position of the dish has finally become clear. I believe that for every being that gives evidence of memory the external world, space, has the form that the being's sensations give it. The external medium is projected into the being in the form of a complex of persistent images." Such speculation scarcely needs comment. It offers nothing helpful in the interpretation of behavior. The author was evidently led astray by the misunderstanding which he has expressed in the following quotation. In discussing the dropping of useless movements in habit formation, he says, "According to this finalistic idea (dropping of useless movements) the rat, knowing by its first trial the position of the water dish, for it must know this in order to modify its path, suppresses its useless movements little by little." This statement reveals an entirely false conception of what is meant by the dropping of useless movements. The expression has been employed to describe what is actually observed in habit formation and to avoid exactly what Cornetz reads into it, the implication that there is conscious purposiveness in the process.

But all this is aside from the chief object of the comparison, which is to show that the rat depends upon the relative position of objects for its orientation, and that the ant probably does not. The first may be admitted without question, but it is extremely doubtful whether the ant possesses a sense of absolute direction in space as the author is inclined to believe. The

evidence advanced is quite inadequate to prove that the ant's method of orientation is in any way different from that of the rat. In the author's various papers, dealing with ants, cases are given in which each of the sensory factors, possibly active in orientation, smell, vision, touch, kinaesthesia, magnetic sense, etc., seem to have been eliminated singly, but no case of correct orientation is recorded in which vision and the muscle sense were eliminated together; indeed the author does not consider the possibility that two or more senses may contribute somewhat independently to the sense of direction. Until such possibilities have been tested thoroughly, it seems unnecessary to invent a sense of absolute direction, "inconceivable," though not necessarily "impossible."

IMITATION

Mammals. Warren (27) reports a case of delayed imitation in the cat. One of two pets formed, through efforts of his own, the habit of climbing into the author's lap, then to his shoulder, and out over his outstretched arm to a piece of meat held on a fork. The companion of this cat made no attempt for months to perform this trick, although watching the trained animal feed in this way daily. This second cat had often been coaxed to make the effort. One day, however, after watching the trained animal feed, he suddenly, of his own accord, sprang on the author's lap, out over his arm and seized the piece of meat. After this he became the sturdy rival of the cat which had first learned the trick.

Hunter (13) finds that the white rat can learn by being "put through" an act. As a part of the daily routine of experiment of the group of rats it was found necessary to deposit each animal, after completing his quota of work, in a small box. This was accomplished by lifting the animal up and dropping him through a hole in the top of a box situated on the table which held the living cage. The animal remained in this box until all the members of the group had been worked with, after which the group as a whole was removed to the living cage and there fed. On the two hundred and fourth day after experimentation had begun the door of the living cage was left open by accident. Two of the five rats climbed to the top of the small box and dropped to the floor of their own accord and

remained there as was their custom during the regular routine of experimentation. A regular set of tests was then initiated. Hunter was able to obtain several performances of a similar kind.

HABIT FORMATION

Amphibia. In connection with his breeding experiments upon the Mexican axolotl (*Amblystoma tigrinum*) Haecker (8) has made a study of learning and retention in relation to sexual and other changes in the individual. The animals were trained to distinguish between pieces of meat and wood of the same size, drawn before them slowly in the jaws of a long pair of forceps. The receptors involved in the discrimination were not very thoroughly analyzed, the author resting content with the statement that vision plays a very slight rôle, while a "special function of the oral sense" and apparently the perception of water currents are the chief factors in the reaction. The question of the impulse to the reaction, hunger, has, on the contrary, been treated at great length. Considerable variation in the degree of hunger was found from day to day, seemingly associated to some extent with atmospheric conditions, but it was found that after the animals had been trained for a month the errors made had little relation to the degree of hunger.

The animals learned readily to distinguish between the meat and the wood and to avoid the latter. The most noteworthy thing about the learning curves is the rhythmic appearance of periods in which numerous errors were made long after perfect learning had been reached. Thus, in the case of a black female which was studied for two and a half years, a large number of errors were made in June, 1910, October, 1910, December, 1910, May, 1911, and the winter of 1911, while the intervening periods were almost without error.

Averaging his results, the author finds that the periods of error are distributed about two maxima, one in summer, one in winter. Once the animals had learned to distinguish between the meat and the wood the errors were not increased by rather long interruptions of training or by fluctuations in the degree of hunger. The two maxima agree with the periods of greatest sexual activity and the author believes them to be the result of the latter; that the physiological changes occurring during

the breeding season affect certain psychic functions not directly connected with reproduction.

Individuals differed considerably in the time of learning and the frequency and extent of the periods of error. Young animals (nine months old) learned with far greater difficulty than mature ones. Among adults three types were distinguishable with respect to the time of learning and retention. Experiments are still in progress to determine whether these types are of selective and hereditary value.

Mammals. Hicks and Carr (11) took up the comparative abilities of human adults, children and white rats to learn a maze. The maze for the man was placed out of doors; its dimensions were fourteen by twenty feet; the alleys were two feet in width, the true path seventy-eight feet in length, complicated by nine *cul de sacs.* The human subject had to run the maze blindfolded. One group of rats learned the Hampton Court maze and another a maze especially constructed by Carr. The results of these experiments show that rats can learn a maze in a fewer number of trials than the human beings. The authors, however, are cautious about adherence to the letter of this conclusion, since the mazes were different and since the criteria of mastery were different, and, further, since only a very small number of individuals were tested. This paper further takes up rather thoroughly the relative ability of the different animals to eliminate errors, distance and excess of time, the relative variability of the three groups, and the relation of the learning curves to intelligence. Under the latter head we find the most complete discussion we have at present of the significance of the form of learning curves. Especially discussed is the significance of the sharp initial drop we find in most learning curves. Since the argument is rather closely connected, the reader must be referred to the original paper.

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LOEB'S "THE MECHANISTIC CONCEPTION OF LIFE"[1]

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This volume brings together ten essays published by the author during the years 1891–1912. The absence of fresh material is more than made good by the convenience of the compilation for readers who desire access to Dr. Loeb's views and who cannot well follow his brilliant but scattered writings in the scientific journals.

The book takes its title from the opening essay, which is a general presentation of the thesis that life phenomena can all be adequately explained in physico-chemical terms, and that no other terms can ever be final. The remaining essays afford specific instances of the application of the thesis, and cover such topics as tropisms, the physiology of the central nervous system, pattern adaptation and physiological morphology, the process of egg fertilization, artificial parthenogenesis, the rôle of salts in the preservation of life, and the influence of environment on animals. In each case experimental evidence is adduced to show how the special phenomena under consideration may be explained by chemical or physical principles.

Only two of the essays contain material directly related to the interests of this journal, i.e., that on tropisms and that on facts and conceptions concerning the comparative physiology of the central nervous system. We shall, therefore, confine our attention to certain issues raised in these chapters, and first consider the case of the tropism. Be it said at once that we waive all discussion of the purely physiological and zoölogical questions upon which the authorities are at variance. It is well understood that Loeb's view of tropistic reactions does not enjoy universal support among zoölogists. For the present purpose we may assume the theory to be correct.

Three propositions substantially express Dr. Loeb's main contentions in the matter. (1) In tropistic organisms, owing to the

[1]*The University of Chicago Press*, Chicago, 1912, pp. 232

peculiar connection of sensitive surfaces with muscle tissue, if physical or chemical stimuli to which such animals are susceptible attack one side of the organism more violently than the other, the muscles of the two sides will be unequally innervated. (2) In animals possessing symmetrical anatomical disposition of muscles this unequal innervation will result in orienting movements tending to bring the organism into a position where the stimulus falls evenly on the two sides, i.e., into a position pointing toward or away from the source of the stimulation. (3) It should be the aim of psychology to reduce all the forms of psychic behavior to the same essentially physico-chemical explanations as are afforded by the knowledge of tropisms. Dr. Loeb's own words on the third point may be quoted: "To me it is a question of making the facts of psychology accessible to analysis by means of physical chemistry." (P. 61).

This pronouncement, which a decade or two ago might have occasioned considerable agitation, will hardly cause a flutter in the psychological breast today. The notion that the practically useful type of explanation of mental events is to be found in terms of neural activities is now almost universally accepted among experimental psychologists. Obviously it is in physical and chemical terms that the final analysis of these neural processes is to be given. The fact that we seem today to be a long journey away from any adequate physico-chemical knowledge about the inner workings of the nervous system detracts not a whit from the theoretical soundness of the position.

The psychological issue which is really raised by this doctrine, although Loeb does not explicitly enter upon it, concerns the necessity for a thorough-going analysis of the psychical facts themselves, and the methods of executing such analysis. To be sure he remarks (speaking of comparative psychology): "But I believe also that the further development of this subject will fall more to the lot of biologists trained in physical chemistry than to the specialists in psychology or zoölogy * * *." (P. 61). How far, however, he recognizes a necessity for a technique of mental analysis as a preliminary to his process of chemical and physical explanation is not clear.

In the case of human behavior at least the need for strictly psychological analysis seems to the present writer so obvious as to be almost truistic, and yet many intelligent persons, not for-

getting some of our medical friends, appear to believe that the psychology of common sense, the kind which supposedly comes by nature, is all that is essential. It appears well-nigh incredible that anyone unfamiliar with the intricacies of the memory processes, as modern psychological analysis has revealed these, should seriously propose to give an adequate physical or chemical explanation of the memory function. It is precisely the peculiarities so disclosed which require explanation. If the physico-chemical explanations of the future are to apply in a vague general way to memory activities loosely conceived and imperfectly analyzed and described, if they are not to afford us an understanding of specific detail, we may find them interesting and suggestive, but in effect we shall be substituting one set of essentially metaphorical terms for another, and our actual advance over present conditions will be relatively slight.

What is true of memory is equally true of auditory and visual sensation, of emotion, of reasoning, of volition and all the rest of the fundamental mental operations. The facts to be physico-chemically explained themselves require an adequate technique of discovery and description. To supply this must be the business of psychology, or some more worthy successor by whatever name known. Psychological facts are no more directly accessible to physical and chemical analysis than they are to deep sea soundings.

What methods are to be accepted and developed for this purpose remains to be determined. This is not the place to discuss the matter. Suffice it to remark that the oldest of the psychological methods, i.e., introspection, is at present under severe fire.

Dr. Loeb's widely quoted analysis of the activities of the central nervous system raises a host of pregnant questions of which only one may be touched upon here, to wit, the conception of "associative memory." "Consciousness is only a metaphysical term for phenomena which are determined by associative memory. By associative memory I mean that mechanism by which a stimulus brings about not only the effects which its nature and the specific structure of the irritable organ call for, but by which it brings about also the effects of other stimuli, which formerly acted upon the organism almost or quite simultaneously with the stimulus in question." (Pp. 73-4).

So far as the issue is one of terms merely, a large latitude should be accorded to personal preference, and if Dr. Loeb finds "associative memory" a more agreeable term than "consciousness," no one may justly object. But if it be supposed that by the use of the phrase "associative memory" any greater insight has been gained into the organic happenings commonly called "conscious," a demurrer may justly be entered. Psychologists have used the term consciousness as a general rubric under which to subsume not only memory and association, but also perception and inference and pleasure-pain and attention, to mention only a few of many constituents. It may be correctly asserted that they have often used the term as though it applied to a specific agent, and have thereby foisted a spurious explanation of certain phenomena upon an unsuspecting public. Not all have fallen into this pit. But even granting this shortcoming, it is not clear that an insight into the essential physico-chemical causes of behavior is any more exact or more tangible when we refer a phenomenon to associative memory, than when we refer it to conscious action. In either case we remain in profound ignorance of the physical and chemical changes which permit that marvelous achievement—the recall of past experiences. We may and do postulate such a property of brain action, but its chemical basis remains as inscrutable when we call it associative memory as when we use the older phrase "organic memory," or when we label it in some other fashion.

One must not impute to Dr. Loeb any indisposition to recognize the force of this contention. He may, or may not, agree with it. But it is fair to call attention to the danger to which his conception exposes him, the danger of failure to take into account the complexities of conscious behavior which psychological analysis has revealed and which await the physico-chemical explanations he so earnestly seeks. The danger is perhaps as great as any to which psychologists are exposed with their meagre knowledge of physical chemistry. It is the danger of a treacherous over-simplification. To make consciousness synonymous with associative memory is thoroughly justifiable if the one really includes all that is in the other. But if, as is all too easy, one has attention fixed largely or solely upon the purely memorial part of the process, much will be overlooked which is not memory at all in any proper sense, and much which requires explanation and interpretation in a peculiarly urgent manner.

On the whole, then, psychologists will wish to speed the day when psychic behavior can be analyzed exhaustively and correlated with the chemical and physical changes in the brain upon which it depends. But there will be more rather than less need in that day for a thorough-going dissection of the psychic process itself, carried out by such methods as may be found adequate. Nor will there be any more eager searchers for accurate knowledge of the brain activities which render memory possible than will be found among the psychologists. But they will hardly feel that a metaphor like 'associative memory' is a satisfactory substitute for what is thus desiderated. Even when the term is applied to strictly physical and chemical activities, it tells us nothing we did not already know. When Dr. Loeb, or any one of his scientific colleagues, is really able to give us the inner chemical and physical facts of brain action, our debt, already great and gladly acknowledged, will be immensely increased.

MORGAN'S "INSTINCT AND EXPERIENCE"[1]

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This book is an outgrowth of its writer's discussion of Instinct and Intelligence in the Symposium held on those subjects in London in 1910 (*cf. British Journal of Psychology*, 3, 1910, 219). In the first half of the book the writer discusses the "nature of instinctive behavior and its accompanying instinctive experience," and then, in the second half, he goes on to present a doctrine of experience, which he regards as the necessary outcome of his theory of instinct, and to which he brings support from many quarters. The views of McDougall, Myers, Stout, and Driesch are repeatedly discussed throughout the volume, while, in addition to other numerous references, an entire chapter (Chap. VII) is devoted to Bergson's philosophy of instinct. The whole presentation has a much more directly logical and epistemological, and a much less directly psychological, bearing, than the title and the author's name would lead one to expect.

The first two chapters are devoted to the discussion of instinct and of instinctive behavior. The latter is said to be "congenitally determined" and "practically serviceable on the occasion of its first performance" (p. 22), whereas the former is instinctive behavior together with the experience that is correlated with it. Although "practically serviceable," instinct is not perfect, and from the first it is subject to modification by intelligence. Intelligence is distinct from instinct with regard to meaning, for the successive phases of the instinctive process in its first occurrence possess "primary meaning," inherent in their mere succession, while upon repetition of the process there is anticipation or "pre-perception" of the as yet unrealized phases by revival of the first occurrence,—an anticipation which supplies "secondary meaning" to the process and characterizes it as intelligent. A vaguely conscious "pre-perception" may accompany the first occurrence of the instinctive performance,

[1]*The Macmillan Co.*, New York, 1912, pp. xvii+299.

instinct and intelligence thus occurring together from the very first, and being separated only by abstraction.

The distinction between instinct and intelligence is made more concrete by reference to the nervous processes involved (Chap. III). The author finds three kinds of behavior: (1) the reflex, which is unconscious and is correlated with processes in the spinal cord; (2) instinctive behavior, which involves "suffused awareness" and is connected with processes in the subcortical centers, and (3) intelligent behavior, which is anticipatory and is confined to cortical processes. He reviews the work of Sherrington, Foster, Schrader, Goltz, and Pagano, and bases his conclusions upon the differences in behavior between normal, decerebrate, and spinal animals.

In Chapter IV we are told of "innate tendencies" or "inherited dispositions," which are due to "congenital connections in cortical centers;" just as instinctive behavior is dependent upon "congenital connections in sub-cortical centers." There are a large number of innate tendencies, which include inherited capacities for acquirement. The vague "pre-perception," which accompanies the first occurrence of instinctive behavior, is due to an hereditary cortical disposition.

The next two chapters deal with the nature of experience and its relation to natural history. Experience, both as "that which may be experienc*ed* and as the process of experienc*ing*," is held to be everywhere interrelated and to be grounded throughout in nature. The unitariness of all experience is not violated by the appearance of new orders in history, for these, although unpredictable, are merely new syntheses in experience.

The last chapter is entitled "Finalism and Mechanism." The writer defends mechanism in the sense that all natural processes are determined and can be correlated. He does not hold, however, that any process can be expressed in terms of any other process, and distinguishes four principles of interpretation,—mechanical, mechanistic (physical and chemical), organic, and psychological. The first two,—possibly the first three,—it may perhaps be possible to merge; the last quite probably must remain distinct. Finalism is accepted only in such cases as involve anticipatory consciousness.

On the whole, the author has succeeded in giving a clear, if sometimes repetitious, presentation of his own doctrine of "the

intra-mundane philosophy of experience." One could wish, however, that the presentation were a little less personal, that it contained fewer references to several of the author's associates, and more references to less immediate philosophical sources. To pass over the doctrines of interactionism and psycho-physical parallelism in half a dozen pages seems hardly fair. One wonders, also, whether a discussion of instinct is the best starting-point for the presentation of a doctrine of experience. The first four chapters might be more intelligible if they followed the last four; and at best it is a question whether there is any gain in presenting the two topics, instinct and experience, in the same volume.

In the discussion of instinct, one is prone to question repeatedly the positive correlation of mental and neural processes. Even granting all the other correlations and the necessity for the "pre-perception" with the first instinctive performance,—a concession which it is not likely that most critics would make,—one is still inclined to wonder in just what way the "pre-perceptive disposition" is proven to be cortical. And yet it is on this fact that the whole theory of instinct depends.

SCHNEIDER'S "TIERPSYCHOLOGISCHES PRAKTIKUM IN DIALOGFORM"[1]

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Four years ago Professor Schneider published a volume of Lectures on Animal Psychology. The lectures were directed against mechanism in physiology and against the "nurphysiologische" psychologists. The writer argued for a panpsychic reservoir, for telic ideas, and for a psychic regulation of the organic functions (*cf. Psych. Bull.*, VII, 1910, 264). The reader who expects to make serious use of the speculations of the *Praktikum* should be familiar with the earlier work.

The plan of the present book is a discussion, dialogue-wise, by representatives from the different biological schools, of the problems of animal psychology and of general biology. A dramatic element is introduced into the dialogues by experimental demonstrations, and it is sustained by sharp repartee, clever thrust and riposte, and even personal censure and professional spite. A bit of characterization also is attempted. *Psychologe* is wise, judicial, impressive; *Biologe* is voluble and assured, but ultimately docile; while *Physiologe*, who represents *der Geist der stets verneint*, comes to his knees, in the end, confesses his sins, and swears allegiance to thc rankest form of teleology. On one occasion, the Lamarckist (a vitalist, a monist and a Darwinian also figure in the discussions) accuses the physiologist of measuring the exactness of scientific research by the number of rabbits consumed in the laboratories. When he proposes to sacrifice, instead, a limited number of thoughts, the physiologist retorts: "Gedanken sind billiger als Kaninchen," to which the Lamarckist curtly rejoins: "Dann wundert's mich, dass man so wenig von Gedanken spürt."

The new work is *echt deutsch gedacht*, and the range of its discussion and of its knowledge is, moreover, limited, for the greater part, to German themes and to German studies. There

[1]*Veit*, Leipzig, 1912, pp. 719.

are three main subdivisions. In the first, discussion and experimentation center in the problems of perception, especially the necessity for a psychical factor in the integration of form. The second part treats of action. Here appear current views regarding the relative importance to organic movements of stimulus, receptor, centre, effector, impulse, telic ideas, will, and psychical energy. The physiologist, *e.g.*, holds to the efficacy of the simple homogeneous stimulus. The Darwinist proposes his *Psychoid*, the biologist his *Gegenwelt*, and the psychologist his "peripheral subject." The title of the third part, *Erfahrung*, refers to the author's theory of consciousness in the higher forms. Chapters are devoted to habit, memory, dreams, play, intelligence, and speech. The final synthesis is principally biological and philosophical speculation. Those who have followed the recent development of speculative biology in Germany will be entertained by the discussion of theories and by Professor Schneider's own constructions.

The comparative psychologist's chief interest in the book lies in the description and the discussion of the experiments. The volume will be useful as a reference book in the laboratory (the illustrations and the index are good), and it might serve—at least in this country—as a point of departure for study in the seminary.